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REPORT OF ACTIVITIES November-December 1990

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Plans are made for 1990-1991 AMLR Field Season

In support of the U.S. Antarctic Marine Living Resources (AMLR) program, the Antarctic Ecosystem Research Group (AERG) prepared for the program's annual field season in the Antarctic. As in past seasons, research will be conducted in the vicinity of Elephant Island at the tip of the Antarctic Peninsula. The field effort will include research conducted from aboard the NOAA Ship *Surveyor* and from a field camp on Seal Island, a small island off the coast of Elephant Island.

The Seal Island field team, led by John Bengtson of the National Marine Mammal Laboratory (NMML), includes Peter Boveng, Don Croll, Mike Goebel, and John Jansen, all of the NMML. After arriving at Seal Island on December 4 with the assistance of the tourist ship the *Society Explorer*, the Seal Island scientists will be studying foraging and reproductive behavior in krill predators.

The NOAA Ship *Surveyor* departed Seattle on December 3, 1990, for Punta Arenas, Chile, where scientists participating in the cruise boarded the ship in early January 1991. The *Surveyor* then left for the study area to begin the first of the two-leg cruise. Each leg of the cruise will last approximately one month, interrupted by a 4-day port call in Punta Arenas. Two broad surveys covering approximately 13,000 square miles will attempt to map the major features of the distribution of water masses, primary production, and krill. Two detailed surveys covering approximately 2,700 square miles will map the distribution of krill in association with the foraging ranges of predators breeding on Seal Island. Observations will include: 1) thermohaline structure, available radiance, and light transmissions in the upper water column; 2) phytoplankton biomass, primary productivity, and nutrient content; and 3) krill distribution, demography, and physiological condition. Additional operations will include: 1) collection of continuous sea surface temperature, salinity, chl-a fluorescence, air temperature, barometric pressure, wind speed and direction, and light levels; and 2) trace nutrient limitation experiments.

Roger Hewitt of the AERG will be cruise leader aboard the *Surveyor* for both legs of the cruise. In addition, Hewitt will lead David Demer (Scripps Institution of Oceanography), Teresa Klinger (UC Riverside), and Susan Chivers (NMFS-SWFSC) in conducting a hydroacoustic survey for krill using an acoustic system recently purchased by the AERG. Rennie Holt, Chief of the AERG, will be aboard for the first part of Leg I, and then will be dropped off at Seal Island where he will take part in research activities. Michael Macaulay (University of Washington) will also be conducting a hydroacoustic survey for krill; Anthony Amos (University of Texas at Austin) will be the principal investigator on oceanographic studies and will be conducting CTD/rosette casts; Osmund Holm-Hansen (Scripps Institution of Oceanography) will be conducting phytoplankton/primary productivity studies; and Valerie Loeb (Moss Landing Marine Laboratories) and John Wormuth (Texas A & M University) will be in charge of studies associated with direct krill sampling. In addition, oceanographers from the Chilean Instituto Hidrográfico de la Armada (IHA) will be launching a series of XBT's during the transits of the Drake Passage. Finally, Martha Ferrario of the University of La Plata in Argentina will be conducting ultraviolet radiation experiments during the *Surveyor's* northbound transit from Valparaiso to San Diego.

The U.S. Antarctic Marine Living Resources (AMLR) program provides information needed to formulate U.S. policy on the conservation and international management of resources living in the oceans surrounding Antarctica. The program advises the U.S. delegation to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), part of the Antarctic treaty system. (J. Rosenberg, FTS 893-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Coastal Division Presentations Given at Colloquium

At the colloquium entitled "Advances in fishery oceanography and recruitment studies at the Southwest Fisheries Science Center," held during the December 1990 NMFS Board of Directors' meeting in La Jolla, various members of the Coastal Division gave presentations. Dr. Paul E. Smith pre-

sented work developed by himself, Dr. Chyan-huei Lo [Nancy] and Dr. John L. Butler on approaches to studying the recruitment processes in the slope and pelagic fish communities. Geoff Moser reviewed the ichthyoplankton research of the CFRD groundfish program and presented a summary of early life history strategies of groundfishes. Ron Lynn reviewed the applicability of various recent technological developments in oceanographic instrumentation to fishery recruitment problems. The following is a summary of these three presentations.

Development of Inexpensive Indices of Recruitment Failure Proposed

Classical fishery management, like that required for Alaska pollack, is geared to the relief of chronic growth overfishing, and depends on the idea that recruitment overfishing can be prevented simply by monitoring the young fish in the years previous to their entry into the fishery. To reduce the chance of inadvertent recruitment overfishing of the schooling coastal pelagic fishes, frequent stock assessments and estimates of recruitment failure will be necessary. Recruitment failure estimates could be ambiguous if conducted too early in the life cycle.

A modification of the Leslie matrix, known as the Lefkovitch matrix, which will allow the least costly detection of recruitment failure, is being used to identify the points in the life history of sardine and anchovy. Normally, the sardine and anchovy coexist in the coastal portions of the major boundary current systems, the eastern and western. The life-history data of these species from extensive laboratory and field studies in coastal portions of the California Current system have been assembled for use in devising procedures for detecting recruitment failure. When completed, this study will jointly evaluate the effects of statistical error of estimation and real interannual changes of the parameters of the life tables.

It appears from preliminary study of the life tables of sardine and anchovy that a simple stock assessment and an estimate of late larval and juvenile lengths and growth rates would be adequate for management purposes. This is because mortality rate is a function of length in the schooling coastal pelagic fishes (i.e. faster growth can be related to greater survival). For example, without change of any other parameter, early juvenile growth of the anchovy of 0.30 mm per day would lead to a stable population size; 0.19 mm per day would lead to 1/5 of the recruitment; and 0.78 mm per day would lead to a five-fold increase in recruitment. A similar phenomenon happens in the late larvae of the sardine. The population matrices are also sensitive to changes in survival rates but the direct estimation of survival (or even abundance) in the late larval and juvenile stages is currently prohibitively expensive. (P. Smith, FTS 893-7169; C. Lo, FTS 893-7123; J. Butler, FTS 893-7149)

Early Life History Strategies of Groundfishes

The Coastal Fisheries Research Division has focused research on the major groundfish species of the deep shelf and continental slope off California, Oregon, and Washington. These include: Dover sole (*Microstomus pacificus*), sablefish (*Anoplopoma fimbria*), shortspine thornyhead (*Sebastolobus alascanus*), and longspine thornyhead (*S. altivelis*). Other species of the slope community of secondary interest are: rex sole (*Glyptocephalus zachirus*), deepsea sole (*Embassichthys bathybius*), and the grenadiers (*Coryphaenoides* spp.). Since 1987 we have conducted six groundfish research cruises to accomplish the following objectives: 1) develop an egg production method for estimating the spawning biomass of Dover sole and sablefish; 2) obtain age, growth, mortality and depth distribution data for key species from trawl hauls; 3) define the structure and ecological parameters of the slope community from analysis of total trawl catches; 4) provide information critical to recruitment estimation from 1) and 2) above, and work out the basic features and strategies of the early pelagic stages that may interact with oceanographic processes to affect recruitment and year-class strength.

Early life history strategies of groundfishes differ markedly from those of pelagic species. Fishes such as anchovies, sardines, and mackerels spawn in epipelagic waters where their larvae develop and eventually produce the new year-class of the stock. Most groundfishes produce pelagic eggs that rise to the surface waters and develop into epipelagic larvae. At the end of the larval period, to survive they must settle to appropriate juvenile habitats which are usually shallower and closer to shore than those of adults. This situation is confounded when larvae are carried offshore by currents, filaments, eddy circulation, and Ekman drift. The highly divergent pelagic stages of key slope species were described in the presentation, as well as possible mechanisms for the settlement of their pelagic young requisite to recruitment. (G. Moser, FTS 893-7129)

Application of Oceanographic Instrumentation to Fish Recruitment Research

Circulation and ocean transport are the most dynamic factors affecting the planktonic life stages of fishes. Those species that have long periods of larval and pre-juvenile life stages are the most vulnerable to large variations in transport. Comparisons between the length and time scale characteristics of planktonic life stages of groundfish, and the length and time scale capabilities of oceanographic instrumentation, aid in determining the applicability of various instruments and design of experiments.

Groundfish have very long planktonic stages (months to a year), and are distributed over great distances. In general, oceanographic instrumentation is adapted to scales that are orders of magnitude smaller. For example, a ship-mounted acoustic Doppler current profiler (ADCP) provides an instantaneous current profile in one spot and, while the ship is in transit, provides a vertical section of velocity in a matter of hours. In that mode it does not provide information on the variation in velocity over time, whereas buoy-mounted ADCP provides time variation information without the spatial information.

Other oceanographic instrumentation discussed in the seminar included Coastal Oceans Dynamics Application Radar (CODAR), current meters, drifters, and satellite remote sensing. Some of these instruments and methods can be used effectively in multiple ship surveys or deployed in arrays of buoys. Combinations of instruments can also be used, depending on the type of information needed and experimental design. One example of matching instrument capabilities to biological sampling requirements is the experiment planned for the Southwest Fisheries Science Center's proposed study of groundfish recruitment and the "spring transition" oceanographic period that annually marks the onset of spring upwelling off the Pacific Northwest coast. There is ample evidence to suggest that the spring transition event can be monitored with a small array of ADCP buoys, by shore-based monitoring of sea level, and by using an ADCP and a conductivity-temperature-depth (CTD) profiler on surveys. (R. Lynn, FTS 893-7084)

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Groundfish and the Oxygen Minimum Zone

Species of the continental-slope, the groundfish community including Dover sole (*Microstomus pacificus*), sablefish (*Anoplopoma fimbria*), longspine thornyhead (*Sebastolobus altivelis*), and shortspine thornyhead (*Sebastolobus alascanus*) are presently being investigated to determine which aspects of their biology critically determine their distribution and abundance. Because all four species have their maximum abundance in the cold, deep, oligotrophic waters of the oxygen minimum zone (OMZ), there is the likelihood that along with biotic interactions, physical factors may have an enhanced role in determining the distribution and abundance of these species. Previous studies have concluded that these species are slow growing and long lived and as such are particularly sensitive to over exploitation.

Associated with the continental slope habitat are several continuous variables and one discontinuous variable. As distance from shore increases, there is generally a decrease in temperature and food availability, and an increase in pressure. In contrast, oxygen decreases rather abruptly to below 0.5% of saturation at about 500 m, remains low to about 1000 m, and increases again to normal saturation levels below that. The four species mentioned above have their peaks of abundance in this oxygen depleted region. The extent to which these species exhibit specific adaptations to this zone and the extent to which other species are excluded from it, will be important predictors of what ecological changes may occur if these four species are depleted.

N. Chin Lai, the NRC fellow for 1990, has completed respiration measurements of Dover sole and the California halibut (*Paralichthys californicus*). Eric Lynn is carrying out parallel measurements of enzyme activity in white muscle of the same species. Juvenile Dover sole and juvenile halibut captured from aerobic, shallow-water habitats have similar metabolic rates and normal scaling relationships for aerobic and anaerobic enzymes. Dover sole that have entered the OMZ are completely divergent from halibut of equivalent size already there. The extremely low levels of both aerobic and anaerobic enzymes of adult specimens inhabiting the OMZ are indicative of a very low metabolism. We are completing our study of enzyme levels in wild fish and laboratory specimens maintained under fully

oxygenated, food replete conditions. By projecting the scaling relationships between enzyme data and respiration rate to the size ranges, we hope to provide a good estimate of field metabolic rates in the OMZ, where only enzyme data are available.

Preliminary studies of whole red-blood-cell oxygen affinities have also been carried out by Lai. The results indicate that the blood of Dover sole is highly adapted to functioning in the oxygen concentrations prevailing in the oxygen minimum zone. The differences between Dover sole and halibut hemoglobins suggest that the OMZ may constitute a specialized habitat that forms a barrier to dispersal of shallow-water forms. We will continue oxygen affinity studies at sea on an upcoming groundfish cruise, where, along with data on the other three target species, we hope to obtain data on the oxygen affinity of the hemoglobin of rex sole (*Glyptocephalus zachirus*), an offshore species whose distribution ends abruptly at the beginning of the OMZ. (R. Vetter, FTS 893-7125)

Population Genetics of Groundfish

Russ Vetter is completing work on the molecular genetics laboratory in the CFRD, SWFSC, which is about 90% complete. We now have the means to collect and store samples, extract DNA, carry out polymerase chain reaction (PCR) amplification of the nucleic acid sequences of interest, run sequencing gels and carry out the analysis of data via a DNA sequence reader. Services including synthesis of DNA primers and automated sequencing are available on a recharge basis from the Center for Molecular Genetics, UCSD. The location of the SWFSC on the grounds of UCSD is a particular advantage due to the diversity of talent and interests in molecular biology in the area. We thank all those who had useful suggestions and input into the creation of the laboratory.

The kinds of studies that will be pursued will include the study of population differences in mitochondrial DNA sequences, allele changes in response to global change, sex determination in spawning stocks and identification of larval fishes through DNA analysis.

Vetter and the rest of the Coastal Division welcome Carol Stepien, the new NRC fellow for 1991. Stepien will begin studies based on mitochondrial DNA sequencing techniques on the population biology of *Sebastolobus* species and other members of the groundfish community. Species that inhabit the continental slope are unusual in that they occupy an extremely wide latitudinal gradient (from the tip of Baja California to the Aleutian Islands), yet they are confined to a thin ribbon of habitat along the slope. The genetic consequences of such a distribution are unknown at this time, but gaining knowledge of species specific sequences will allow the development of species specific larval markers in the future. (R. Vetter, FTS 893-7125)

SURVEY SYSTEMS DEVELOPMENT AND EVALUATION

Sexual Maturity of Dover Sole

John Hunter, Nancy C. H. Lo, Beverly Macewicz, and Carol Kimbrell analyzed histology data from Dover sole collected from 1985 to 1989 in California and Oregon waters to determine the optimal criteria for sexual maturity in Dover sole. The histological observations of Macewicz are arranged into six sets of maturity criteria (Table 1). The first set of criteria identifies females with either advanced

Table 1. Six sets of histological criteria for female sexual maturity in Dover sole with the mean length of the females in each set.

		Histological criteria for maturity o = Not present + = Present - = Not considered											
Criteria set number	Certainty	Advanced yolked oocytes		Post-ovulatory follicles	Early Yolked oocytes		Unyolked oocytes			Mean length (mm)		Numbers of females California + Oregon (N = 2595)	
		With α atresia	No α atresia		With β atresia	Only α atresia or none	With β atresia	With α atresia	No atresia	$\bar{x}$	±2SE	Number in class	Cumulative percent
1	Certain maturity	+	+	+	-	-	-	-	-	434	±3	1343	52
2	Uncertain	o	o	o	+	-	-	-	-	414	±7	218	60
3	Uncertain	o	o	o	o	+	-	-	-	397	±11	77	63
4	Uncertain	o	o	o	o	o	+	-	-	379	±6	279	74
5	Uncertain	o	o	o	o	o	o	+	-	350	±5	432	90
6	Certain[1] immaturity	o	o	o	o	o	o	o	+	297	±10	246	100

[1]Defined as certain immaturity because no histological evidence exists for maturity.

yolked oocytes, or postovulatory follicles. The sexual maturity of these females is certain, although some mature females may be excluded if the first set of criteria alone, is used. Criteria sets two to five, if added to the first set, broaden the maturity definition to include females having ovaries in the earliest stages of vitellogenesis and those showing possible signs of past reproductive activity (beta or alpha stage atresia). Each additional criteria set that one might add to the first set increases the risk that immature fish will be classed as mature. Females in set six are considered to be immature because they have none of the characteristics mentioned in the other five sets.

Use of beta stage atresia in criteria sets two and four as a possible sign of past reproductive activity seems justified. Females with early yolked oocytes and beta atresia (set two) were larger on the average than those with no beta atresia (set three) ($t=2.64$, $p<0.01$, $DF=154$), and females with unyolked oocytes and beta atresia (set four) were larger than those with only alpha atresia (set five) ($t=7.54$, $p<0.001$, $DF=551$). In addition, the ranking of criteria sets based on an intuitive appraisal of the risk of classification error is largely born out by the length distributions of the females identified by the criteria set. The mean length of females identified by a criteria set decreased with criteria set number (Figure 1).

An age-length key regression approach was used to estimate the fraction of mature females from an entire data set based on two equations:

$$p_{j|i} = p_{m|i}\, p_{j|m} + (1-p_{m|i})\, p_{j|im} \qquad (1)$$

where $p_{j|i}$ is the fraction of fish of length class j in the i^{th} criteria set. $p_{j|m}=p_{j|1}$ and $p_{j|im}=p_{j|6}$, because criteria set one consists of all mature fish and criteria set six consists of all immature fish, and the overall fraction of mature fish in the i^{th} criteria set ($p_{m|i}$) increases linearly with criteria set number i:

$$p_{m|i} = b_1 + b_2 \cdot i \qquad (2)$$

Combining equations (1) and (2) provides the final model

$$y_{ij} = b_1\, x_{1j} + b_2\, x_{2j} \qquad (3)$$

where

$$y_{ij} = p_{j|i} - p_{j|im}$$

$$x_{1j} = p_{j|m} - p_{j|im}$$

$$x_{2j} = i\,(p_{j|m} - p_{j|im})$$

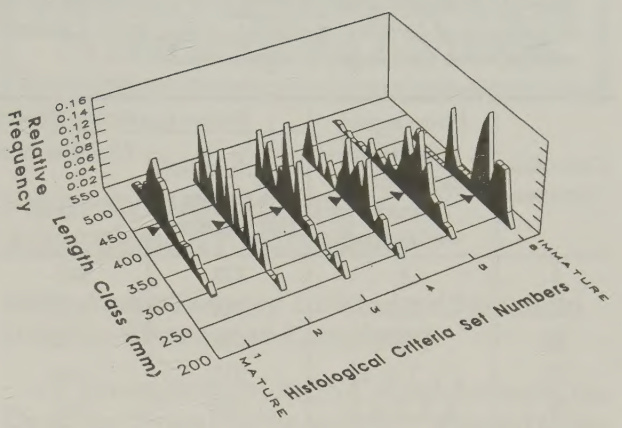

Figure 1. Relative frequency before spawning of Dover sole females in 10 mm length classes for six histological criteria sets. The arrow indicates the mean length for each distribution.

The mean length at 50% mature (ML50) was estimated using the maturity fractions based on the model (Equation 3) as well as a series of maturity definitions that include progressively more criteria (Table 2). When the definition of sexual maturity is expanded by progressively adding criteria 2 through 5 to the definition, the ML50 decreased for each additional set of criteria added. Our ML50 estimate from the model of all females taken prior to the spawning season was 332 mm and is most similar to maturity definition IV. Thus, definition IV was chosen as the least biased for determining sexual maturity (Table 2). Inspection of Table 2 also indicates that the length at 50% maturity is always greater when measurements are made during the reproductive season rather than before it begins, regardless of the number of criteria sets used to define sexual maturity. This implies that during the spawning season, the ovaries of some post-spawning females are reabsorbed to the extent that they become indistinguishable from females defined as immature. Thus, maturity should be estimated prior to the onset of spawning and the definition of maturity should be broader than definition I.

The preferable estimate of 50% mature is believed to be the one based on the model using data taken before the spawning season. This method demands detailed histological classification which may be too costly for many purposes. Definition III, could be used if tissue were examined microscopically or with a strong hand lens, and it gives values

Table 2. Estimated mean length at which 50% of Dover sole females are sexually mature using six histological definitions of ovarian maturity. Data, from California and Oregon taken before and during the spawning season, were fit using the logistic model.

Definition number	Histological critera sets included in maturity definition[1]	Before spawning (N=854 females)			During spawning (N=1321 females)		
		Length at 50% maturity (ML50, mm)	Number of mature females		Length at 50% maturity (ML50, mm)	Number of mature females	
			N	Percent of all females captured		N	Percent of all females captured
I	1	373	541	63	419	568	43
II	1, 2	361	582	68	396	692	52
III	1, 2, 3	348	626	73	391	720	54
IV	1, 2, 3, 4	332	669	78	348	917	69
V	1, 2, 3, 4, 5	258	810	95	255	1184	90
MODEL	1, 2, 3, 4, 5, 6	332	691[2]	81[2]	389	742[2]	56[2]

[1]From Table 1.
[2]Estimated from model.

close to those provided by the model. (N. Lo, FTS 893-7123)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Bathymetric Data

Larry Jacobson and Larry Eber have been working with the National Ocean Service (NOS) Extended Jurisdiction Program to obtain detailed bathymetric data for the west coast. The data will be used to enhance groundfish research at the Center. (L. Jacobson, FTS 893-7117; L. Eber, FTS 893-7167)

Groundfish Management

Dale Squires, as part of the Groundfish Management Team, has been estimating likely effects of alternative trip limits on trawl vessels in the deepwater fishery for Dover sole, sablefish and thornyheads. Among the alternatives considered were trip limits on thornyheads and on the entire deepwater complex. At the meeting in November, the Pacific Fishery Management Council decided to impose trip limits for thornyheads and switch to a larger minimum mesh size (4-1/2 inches) for bottom trawls. While trip limits for thornyheads generated a considerable amount of discussion, the mesh size limit, which was an attempt to reduce reliance on trip limits, enjoyed broad industry support. (D. Squires, FTS 893-7111)

Economic Analysis of Proposed Black Rockfish Harvest Limits in Washington Coastal Waters

Industry Economist Cindy Thomson responded to a request by the Pacific Fishery Management Council's Scientific and Statistical Committee (SSC) for an economic analysis of changes in harvest limits for black rockfish (*Sebastes melanops*) proposed by the Washington Department of Fisheries (WDF). Her analysis was conducted with the assistance of Brian Culver (WDF).

Studies conducted by the WDF suggest reduced availability since 1987 of black rockfish in coastal areas of Westport and Neah Bay. The studies also suggest that abundance has remained relatively high in areas that have not been heavily used by commercial and recreational fisheries. In order to reduce fishing mortality and potential conflict among user groups, the WDF recommended that: 1) the recreational bag limit for all species of rockfish be reduced from 15 fish to 12 fish per angler trip; 2) commercial jig fishing be restricted to the area between 47°40'N and 48°9.5'N; 3) incidental harvest of black rockfish by hook-and-line vessels (other than commercial jig vessels) be limited to 100 pounds or 10% of total catch of all species, whichever is greater.

On the basis of her analysis of data for recent years, Thomson predicted that the proposed 12-fish

bag limit on rockfish would have an insignificant effect on jetty and private boat anglers. It would, however, affect the charter boat segment of the recreational fishery by reducing keep rates for approximately two-thirds of angler trips and reducing annual bottom fish harvest by at least 10%. The effect on angler participation (due to the drop in keep rates) could not, however, be predicted from available data. In lieu of predictions, Thomson performed a sensitivity analysis in which she estimated the effect of the proposed bag limit on consumer surplus for anglers and charter boat revenues and profits under varying assumptions about angler response to the bag limit. Consumer surplus, in this context, is the benefit measured in dollars, that anglers obtain over and above what they spend on fishing.

The effect of the proposed area restriction on the commercial jig fleet was difficult to evaluate, since the extent to which the fleet customarily operated in the proposed area was unknown. To the extent that the area restriction would make it necessary for vessels to extend their customary geographic range of operation, area restrictions would also increase their operating costs and perhaps cause some vessels to permanently leave the fishery. Vessels based in Neah Bay or Westport for example, might have to move their operation to La Push. These changes could modify the supply of fish available to buyers in various ports.

The proposed limit on incidental take is expected to have an insignificant effect on longliners and salmon trollers, which have historically harvested small amounts of black rockfish. The incidental take limit, however, was expected to have a significant effect on a small number of bottom fish trollers. For the small number of affected vessels, the limitation on incidental take could potentially result in a 20% decline in total ex-vessel revenues from bottom fishing.

The WDF presented Thomson's analysis to the SSC and the Council at the November meeting. After minor modification, the WDF's proposals were sent to the Department of Commerce for review. (C. Thomson, FTS 893-7116)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

FISHERY INDEPENDENT ASSESSMENT PROGRAM

Fifth Annual Survey to Monitor Trends in Dolphin Abundance Completed

On December 6, two NOAA research vessels, the *David Starr Jordan* and the *McArthur*, returned to San Diego after participating in a 4-month survey counting dolphins and assessing their habitat in the eastern tropical Pacific Ocean (ETP).

The Southwest Fisheries Science Center (SWFSC) is responsible for monitoring the status of stocks of dolphins which are incidentally killed during tuna purse-seining activities in the ETP. This is the fifth in a series of six annual research vessel surveys to monitor trends in abundance of dolphin stocks.

The primary objective of the cruise was to collect information to estimate the density, size, and species composition of dolphin schools in the ETP in order to determine the trends in population sizes. Other objectives included the collection of information to investigate the physical and biological environment of dolphins, and also to collect data to contribute to ongoing U.S. and international interactions in the ETP.

The results of the surveys are being compiled for the purpose of presenting a report to Congress prior to the reauthorization hearings for the Marine Mammal Protection Act, which begin in the spring of 1992. A series of workshops will be held in 1991 and early 1992 to review reports on trends in abundance and stock structure. In addition, those data will be used to assist NMFS and the IATTC in negotiating an international agreement to reduce porpoise mortality over the next 5 years. (D. DeMaster, FTS 893-7165)

Marine Mammal Surveys

The surveys were conducted by maintaining a visual watch using two 25-power binoculars with a maximum ship-to-horizon sighting distance of approximately 6 nautical miles. Generally, all schools encountered within 3 nautical miles were approached to confirm identification and obtain

school size estimates. Table 1 lists the preliminary results of cetacean school sightings collected from both the *McArthur* and the *Jordan*.

Preliminary calculations from the *Jordan* indicate that 594 schools of marine mammals were sighted. Of the total schools, 16% were seen on Leg 1, 32% on Leg 2, 28% on Leg 3, and 24% on Leg 4. Thirty-five percent of all schools sighted (208 schools) contained target species. Figure 1 shows the tracklines completed by the *Jordan*.

Preliminary calculations from the *McArthur* indicate that 518 schools of marine mammals were sighted. Of the total schools, 20% were seen on Leg 1, 30% on Leg 2, 32% on Leg 3, and 18% on Leg 4. Thirty percent of all schools sighted (156 schools) contained target dolphins. Figure 2 shows the tracklines completed by the *McArthur*.

Table 1. Preliminary number of cetacean school sightings collected from the NOAA Ships *David Starr Jordan* and *McArthur* during the 1990 eastern tropical Pacific dolphin survey.

	Leg 1	Leg 2	Leg 3	Leg 4	TOTAL
Spotted dolphin	22	35	31	14	102
Spinner dolphin	15	7	10	23	55
Common dolphin	2	14	19	18	53
Striped dolphin	28	47	44	29	148
Rough-toothed dolphin	8	7	4	5	24
Bottlenose dolphin	7	4	21	13	45
Risso's dolphin	0	5	18	8	31
Pacific white-sided dolphin	0	0	0	1	1
Fraser's dolphin	1	4	0	1	6
Unident. dolphin	37	76	54	44	211
Pygmy killer whale	3	2	5	1	11
Pilot whale	12	14	23	8	57
Killer whale	2	5	3	6	16
Sperm whale	2	10	13	4	29
Dwarf sperm whale	1	1	3	3	8
Melon-headed whale	0	2	0	0	2
Beaked whale	7	16	15	8	46
Mesoplodon whale	5	11	6	11	33
Rorqual whale	7	11	17	5	40
Bryde's whale	8	12	7	9	36
Blue whale	0	2	6	1	9
False killer whale	2	2	1	2	7
Minke whale	0	0	0	1	1
Humpback whale	0	1	3	0	4
Unident. small whale	11	4	3	2	20
Unident. large whale	4	21	10	11	46
Unident. whale	8	20	6	4	38
Unident. cetacean	7	10	9	7	33

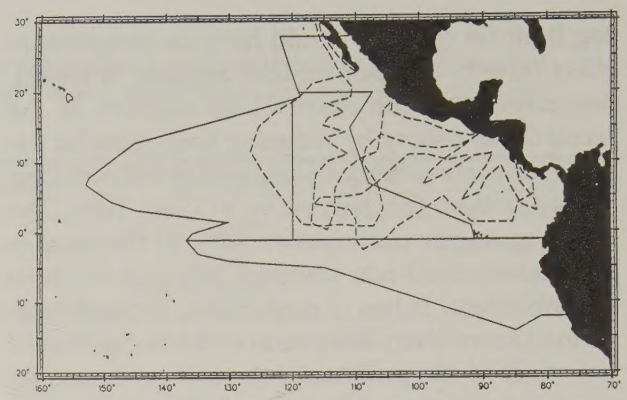

Figure 1. Tracklines completed by the *Jordan* in 1990.

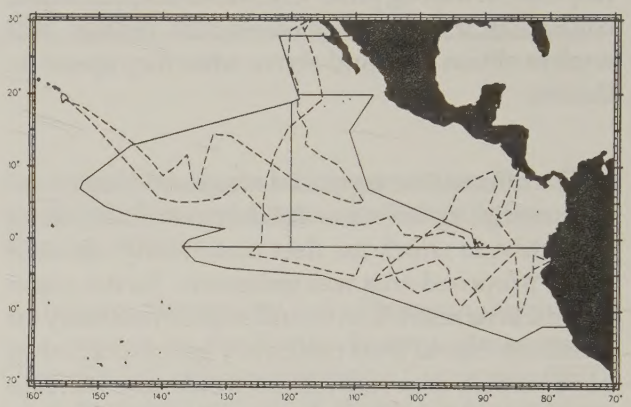

Figure 2. Tracklines completed by the *McArthur* in 1990.

After data entry and editing, the survey data will be analyzed, using line-transect analysis, and compared to surveys in previous years. (T. Gerrodette, FTS 893-7131)

BIOLOGICAL ASSESSMENT PROGRAM

Photogrammetry - Aerial Photographs Taken to Calibrate School Size Estimates

In addition to these daily marine mammal watches, the *Jordan* used a helicopter to photograph dolphin schools from the air. During optimal weather conditions (clear skies and sea state beaufort 0 through 3), the helicopter flew two photographic missions per day to obtain aerial photographs from which accurate counts of school size and composition can be made. After a sighting was made, observers on the vessel made school size estimates and the biologists onboard the helicopter photographed the school. Estimates made by ves-

sel observers can be calibrated by comparing them to the counts made from the aerial photographs.

During the survey, the helicopter flew a total of 110.4 hours (13.4 of those hours consisted of pinniped and bird surveys, and training flights). A total of 43 days was spent photographing cetaceans, averaging 2.3 hours per day. Sixty-eight schools of small cetaceans and 6 whale schools were photographed from the helicopter during this time. (W. Perryman, FTS 893-7014)

Dolphin Tissue Samples for Use in Stock Identification Collected

Both vessels collected cetacean tissue samples for genetic analysis using a low-powered crossbow. Thirty-two tissue samples were collected from six different species of marine mammals. Mitochondrial DNA analysis will be conducted on these samples to determine any discernable stock differences within the species. (A. Dizon, FTS 893-7089)

DOLPHIN ECOLOGY PROGRAM

1990 MOPS Environmental Data Collection Completed

Continuous data on temperature and salinity of surface water were collected and recorded digitally. After sunset and before sunrise the vessel stopped for two 1-hour stations. At these stations, vertical conductivity-temperature-depth (CTD) measurements and sea water samples were collected. Some samples were analyzed for chlorophyll and salinity. Other samples were frozen and returned to the SWFSC for nutrient analysis. Carbon-14 uptake was measured by incubating morning samples on deck.

Both vessels launched a combined total of 809 expendable bathythermographs (XBTs) and conducted 368 CTD casts and 282 dipnet stations. Collections of specimens by both vessels included 20 birds for stomach content analysis, 1461 flying fish, and 79 fish stomachs.

During approximately 1690 hours of combined searching effort, 8271 sightings of birds were recorded. Seabird visual censuses were conducted during daylight hours using 7-power hand-held binoculars. Birds sighted within 300 meters of the track line were recorded, following strip-transect methodology. Sea turtles were counted, photographed, captured and tagged on an opportunistic basis. A total of 242 turtles was sighted during the 4 month survey. Aboard the *Jordan*, 19 turtles were captured, tagged, and released. A satellite transmitter was attached to one adult male olive ridley turtle and is currently sending location, dive depth, and surface data to the SWFSC. A detailed ecosystem report for both vessels will be completed by mid 1991. (S. Reilly, FTS 893-7164)

COASTAL MARINE MAMMAL PROGRAM

Censusing of Northern Elephant Seals Using Aerial Photography

Fishery Biologists Mark Lowry and Wayne Perryman have been monitoring the population of northern elephant seals (*Mirounga angustirostris*) at San Miguel Island during the winter breeding season using counts from large format color aerial photography. Low level (800-1000 feet) vertical photographs were taken from an aircraft equipped with either a 9-inch format camera (1985 and 1986) or a 5-inch format camera (1988 through 1990). During the censusing period, one flight is made in late January or early February when most adults are breeding (peak season) and a second flight is made in mid to late February (late season) for counting the maximum number of pups produced during the breeding season. The elephant seals are then counted on a light table equipped with a 0.7-7X zoom binocular microscope. The original images are overlayed with clear acetate and each seal is marked and counted.

After a pilot study demonstrated that northern elephant seals could be accurately counted from vertical photographs, all known breeding sites at San Miguel Island were subsequently photographed annually. Results of total island counts for 1985, 1986, and 1988 through 1990 show an increase in pups (Figure 3) and adult males (Figure 4) over the 6 year period. We also found that the number of peak season females plus weaned pups very closely approximates the late season pup count.

Elephant seals are ideally suited for aerial photographic sampling because of their large size and dramatic sexual dimorphism. While their breeding aggregations, which may include several thousands of individuals, are impenetrable from the ground, each individual can be classified and counted in the aerial images. Sampling photographically also prevents disturbance to the seals during this critical part of the breeding season. (M. Lowry, FTS 893-7174; W. Perryman, FTS 893-7014)

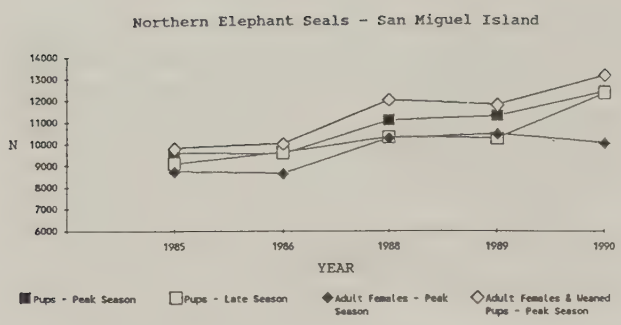
Northern Elephant Seals - San Miguel Island
N
YEAR
Pups - Peak Season
Pups - Late Season
Adult Females - Peak Season
Adult Females & Weaned Pups - Peak Season

Figure 3. Northern elephant seal pups and adult females from color aerial photographs taken at San Miguel Island, California.

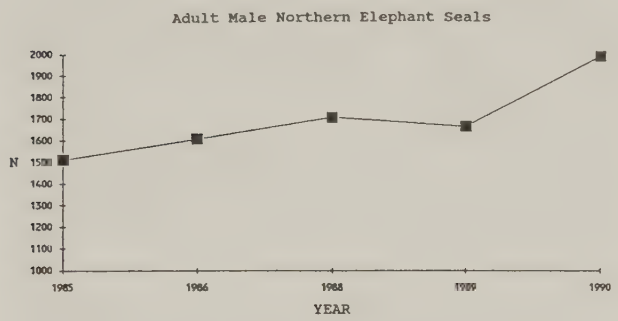

Figure 4. Adult male northern elephant seals counted from color aerial photographs taken at San Miguel Island, California.

Censusing of California Sea Lion Pups Using Aerial Photography

Fishery Biologists Mark Lowry and Wayne Perryman have been monitoring the number of California sea lion (*Zalophus californianus*) pups at San Miguel Island during the summer breeding season by using large format aerial color photography. During flights made between July 17-26, low level (600-900 feet) vertical photographs were taken from an aircraft mounted with either a 9-inch format camera (1986) or a 5-inch format camera (1987 through 1990). California sea lion pups were counted with a Hoppman Viewer Enlarger, set at a magnification of 19X, which projects the image onto a 35 cm frosted glass screen. A clear piece of 0.003 or 0.005 mylar plastic is anchored over the glass screen of the viewer and the image of the pups is marked with a pen as each is counted with a hand counter. From 1986 through 1990 between 11,000 and 12,800 California sea lion pups have been counted per year using aerial photographs (Figure 5). The lowest pup count obtained was in 1988 when 11,055 pups were counted; the highest pup count was obtained in 1987 when 12,807 pups were counted. Although a comparison of aerial photo

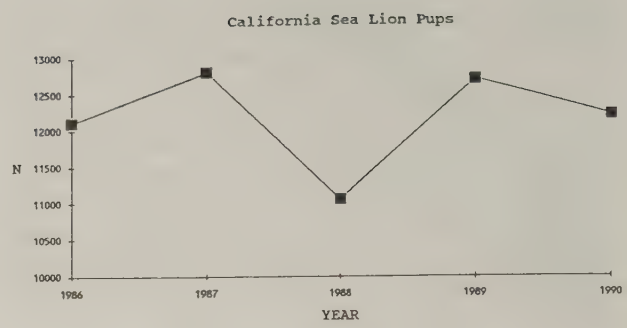

Figure 5. California sea lion pup counts from color aerial photographs taken at San Miguel Island, California.

pup counts to traditional ground counts has not been made, the aerial photographic census technique has demonstrated that large numbers of pups can be counted. (M. Lowry, FTS 893-7174; W. Perryman, FTS 893-7014)

HONOLULU LABORATORY

Honolulu, Hawaii

MARINE MAMMALS AND ENDANGERED SPECIES

Workshop Held on Marine Turtle Tumor Disease

For the first time, scientists working on fibropapilloma, a life-threatening tumor disease in the green turtle (*Chelonia mydas*), had the opportunity to share their research on the disease. The Marine Turtle Fibropapilloma Disease Workshop, sponsored by the Honolulu Laboratory of the Southwest Fisheries Science Center, brought 10 scientists from across the United States to Honolulu, Hawaii, during December 4-6, 1990 (Figure 1).

The green turtle, which occurs worldwide in tropical and subtropical seas, is a protected species under the U.S. Endangered Species Act. Turtles afflicted with fibropapilloma have disabling tumors that can grow up to 12 inches in diameter and may eventually lead to death. The tumors occur at a number of locations on turtles, including: in their mouths, throats and nasal passages, hindering breathing and making eating difficult or impossible; on their eyes, severely impairing vision and increasing their vulnerability to predators; and on their jaws, necks, tails, and flippers, impairing movement and swimming ability.

Figure 1. Participants of the Marine Turtle Fibropapilloma Disease Workshop held in Honolulu, Hawaii, December 4-6, 1990. Front row (from left to right): John Harshbarger, Wendy Teas, Elliott Jacobson, Murray Dailey, Alvin Smith, and John Sundberg. Back row (from left to right): Jim Swensen, Sam Pooley, George Balazs, Sidney Simpson, Lew Ehrhart, and George Boehlert.

So far, scientists do not know what causes fibropapilloma in the turtles, how it is spread, or what the impact of the disease will be on the recovery of the Hawaiian green turtle.

The workshop gave scientists an opportunity to share what they know about the disease based on current research. After discussing possible causes of the disease, ranging from a virus, to parasites to environmental pollution, the scientists devised a comprehensive cooperative research plan to determine the cause of the disease and to use in seeking additional financial support for such research.

The research plan, along with an overview of what is known about fibropapilloma, will be presented in a technical report scheduled for completion in February 1991. Research activities listed in the plan range from conducting tumor tissue culture studies, to performing chemical and toxicology analyses of turtles and their environment.

With the number of reported cases of the disease mounting, and its geographic spread increasing, the timing of the workshop was critical. Although the disease was first observed in the late 1920s in the Florida Keys and in 1958 in Kaneohe Bay, it has spread simultaneously in both areas and reached epidemic proportions at certain sites in Hawaii and Florida during the past few years. Until recently, the disease was believed to be exceedingly rare in other areas; however, in the past few months, a number of cases have been reported in Australia and the Caribbean Islands.

The workshop gave scientists an opportunity to visit one of the locations off the Hawaiian island of Oahu, Kaneohe Bay, where reports of the disease have increased dramatically in the past few years. During the Kaneohe trip, which was hosted by the Hawaii Institute of Marine Biology at Coconut Island, visiting scientists observed Honolulu Laboratory researchers hand-capturing turtles for tagging. Of the seven turtles captured that day, six were afflicted with tumors. The Kaneohe trip brought the gravity of this situation to life for those scientists who have analyzed tissue from the tumors but had never seen tumor-inflicted turtles.

The scientists also visited Sea Life Park's sea turtle facilities which have had no cases of the disease, and later attended a dinner hosted by the park.

The tumor disease was designated the number one research priority in the draft Hawaiian Sea Turtle Recovery Plan. The plan is still under review by officials of the National Marine Fisheries Service (NMFS) in Washington, D.C.

Scientists who discussed research results at the workshop and developed the research plan included George H. Balazs, George W. Boehlert, and Samuel G. Pooley, all of the Honolulu Laboratory; Murray D. Dailey, California State University; Lew Ehrhart, University of Central Florida; Wallace Hansen, U.S. Fish and Wildlife Service; John C. Harshbarger, National Museum of Natural History, Smithsonian Institution; Elliott Jacobson, University of Florida; Laurence Kolonel, Cancer Research Center of Hawaii; Sidney Simpson, University of Illinois; Alvin W. Smith, Oregon State University; John Sundberg, The Jackson Laboratory; Wendy Teas, NMFS Miami Laboratory. Also attending the workshop was Izadore Barrett, Research and Science Director of the Southwest Fisheries Science Center. (G. Balazs (808) 943-1240)

Hawaiian Monk Seal Recovery Team Meets

The Hawaiian Monk Seal Recovery Team (Figure 2) met December 3-5, 1990, at the Honolulu Laboratory. The nine-person team advises Southwest Regional Director E. Charles Fullerton on research and management actions necessary to ensure the recovery of the endangered Hawaiian monk seal (*Monachus schauinslandi*).

Under the direction of Robert L. Brownell, Jr., of the U.S. Fish and Wildlife Service, the team reviewed recent data on monk seal populations as

Figure 2. Hawaiian Monk Seal Recovery Team members (from left to right): Doug DeMaster, Paul Kawamoto, Ancel Johnson, Lee Eberhardt, Bob Brownell, Ian Stirling, Bob DeLong, Bill Gilmartin, and Gene Nitta.

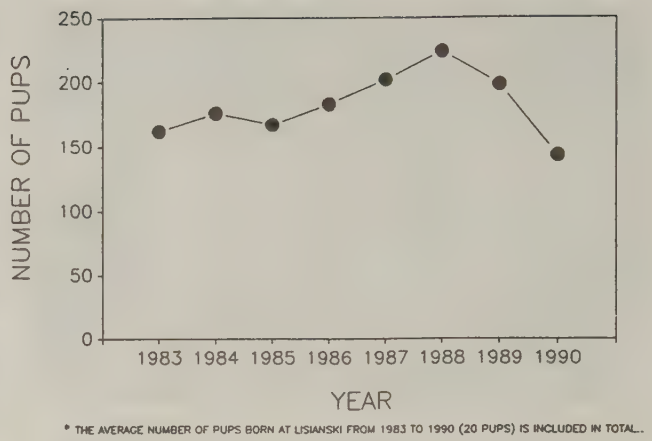

Figure 3. Number of Hawaiian monk seal pups born at the five major breeding sites, 1983-90.

well as the progress of research and actions conducted by the Marine Mammals and Endangered Species (MMES) Program. Among the topics covered were: the possible monk seal and fishery interactions in the burgeoning longline fishery for swordfish; decreased pup production in recent years; future research into the causes of mass attacks by adult male seals on adult female and immature animals, and research into solutions to this problem; increased monitoring by the MMES Program of populations at Pearl and Hermes Reef; continuation of the Kure Head Start Project and rehabilitation of underdeveloped pups; and actions necessary to increase the small population of seals at Midway. The full text of the team's recommendations is available from the Southwest Region. (W. Gilmartin (808) 943-1239)

Births of Hawaiian Monk Seals Decline in 1990

Births of Hawaiian monk seals declined in 1990 for the second straight year, constituting the lowest total since the MMES Program began monitoring all major breeding locations in 1983 (Figure 3). Hawaiian monk seals give birth on eight of the remote Northwestern Hawaiian Islands, and MMES Program personnel annually tag pups and monitor births at the five major breeding sites (Kure Atoll, Pearl and Hermes Reef, Lisianski and Laysan Islands, and French Frigate Shoals). Births at these locations totalled 143 in 1990, a 23% decrease from the 1983-89 average, and 37% below the 1988 high.

Environmental factors, such as diminished food resources, may have caused the decline. The number of adult female seals was approximately the same in 1990, so the observed decline was the result of fewer females giving birth. Pups born in 1990 were conceived in 1989, and the 1989-90 winter may have been a lean one. When food resources are low, female seals of other species may not give birth and pups may be born undersized. Notably, pups born in 1989 had low girths at weaning. (J. Henderson (808) 943-1225)

NOAA Scientist Attends Emergency Meeting on Mediterranean Monk Seals

An emergency meeting on the endangered Mediterranean monk seal (*Monachus*) was attended by William Gilmartin on the island of Texel in the Netherlands, December 10-11, 1990. Gilmartin, who is the leader of the MMES Program, was invited to participate in the meeting because of his expertise in the biology of the Hawaiian monk seal, a cousin of the Mediterranean species; little is known about the biology of Mediterranean monk seals.

The emergency meeting was called by the Commission of the European Communities in response to recent concerns that the Mediterranean monk seal may be threatened by a virus, morbillivirus, which in recent years has killed thousands of grey seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) in the North Atlantic, and striped dolphins (*Stenella coeruleoalba*) in the Mediterranean. Over the past few years, populations of the Mediterra-

nean monk seal have shrunk in size to no more than the few hundred that exist today. In contrast, its Hawaiian counterpart has about 1,500 individuals.

One recommendation resulting from the meeting was for scientists to begin testing a vaccine, used before on harbor and grey seals, to see whether it can be used for Mediterranean monk seals. Gilmartin has agreed to work cooperatively with European scientists in evaluating the vaccine in captive animals. If the results indicate that the vaccine will work, Gilmartin will then travel to the Atlantic coasts of Mauritania and Morocco in the spring of 1991 to assist in vaccinating Mediterranean monk seals in the wild.

Other recommendations based on the continuing decline of the Mediterranean monk seals included the initiation of a captive breeding program. Such a program may be a viable option, as suggested by the successful rehabilitation and maintenance of Hawaiian monk seals by the MMES cooperative program with Sea Life Park and the Waikiki Aquarium.

Participants at the meeting were representing the Seal and Captive Breeding Specialist Groups of the International Union for the Conservation of Nature, and the Hawaiian Monk Seal Recovery Team of which Gilmartin is a member. (W. Gilmartin (808) 943-1239)

FISHERIES OCEANOGRAPHY RESEARCH PROGRAM

Distribution of Larval and Juvenile Fishes Assessed Around Palmyra Atoll

During *Townsend Cromwell* cruise 90-07 in August and September 1990, biological and oceanographic sampling was conducted in waters surrounding Palmyra Atoll by Fishery Biologists George Boehlert and Bruce Mundy, Oceanographer Christopher Wilson, and Biological Aide Ronald Yoshimoto, along with Ilse Hamann from the University of Hawaii's Joint Institute of Marine and Atmospheric Research. The principal goal of the cruise was to assess the distribution of larval and juvenile fishes relative to ocean currents and to the physical environment surrounding an isolated oceanic island.

A variety of sampling techniques were used to collect physical oceanographic data: Expendable bathythermographs (XBTs), conductivity-temperature-depth (CTD) casts, acoustic Doppler current profiler (ADCP), and ARGOS satellite drifters. The first series of CTD and XBT stations and ADCP measurements were made along a transect from 10°N, 163°W, to 5°N, 163°W, to determine the axis and velocity of the equatorial countercurrent upstream of Palmyra Atoll. The ADCP data were collected at virtually all times that Global Positioning Systems (GPS) satellite data were available. These data were processed in near real time aboard the vessel to provide assessment of currents during sampling activities. Current velocities measured during the transect were very high and reasonably unidirectional at the latitude of Palmyra Atoll, 5°48'N (Figure 4). This was confirmed by the tracks of ARGOS drifters deployed upstream of the atoll (Figure 5).

Young stages of fishes were collected with five types of gear, including a 1 m^2 MOCNESS plankton net, a Manta neuston net (0.7 x 0.7 m), a *Cobb* midwater trawl, a 1 m plankton drop net, and a light trap. Only about one-half of the *Cobb* trawl samples were taken because of winch failure, but the catches were fairly sparse and generally dominated by the engraulid *Encrasicolina punctifer*. The MOCNESS and Manta stations were occupied at night in a grid surrounding the island (Figure 6). Each point included a Manta sample plus replicate MOCNESS samples at three depth intervals, from the bottom of the mixed layer (110-130 m) to 70 m, 70-30 m, and

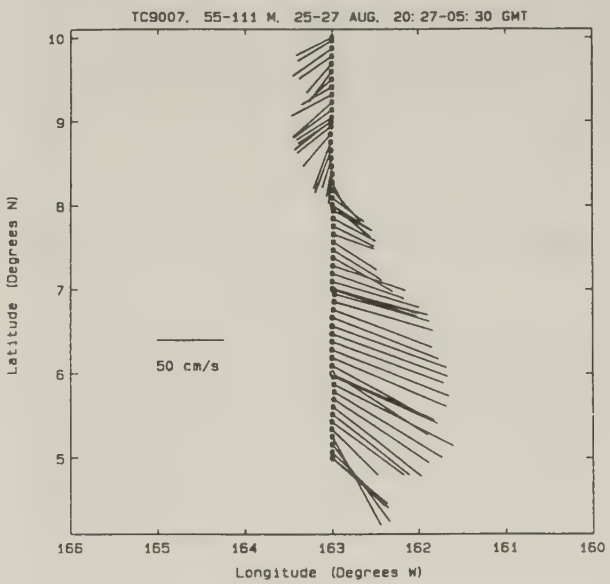

Figure 4. Ocean currents at 55-111 m depth derived from the acoustic Doppler current profiler along the 163°W section. Each vector is based upon a 30 m average, and the maximum current velocity is 105 cm/sec. The eastward flowing countercurrent is clearly evident.

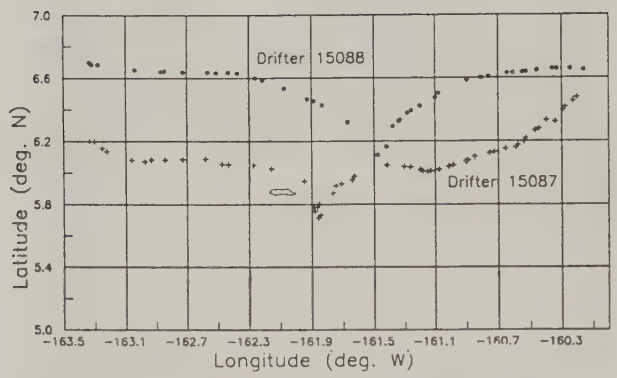

Figure 5. Tracks of two ARGOS drifters released upstream of Palmyra Atoll. The drogues are standard TOGA/WOCE holey sock drifters drogued to represent currents at 15 m depth. The overall average speed from start to finish of each track was 39.61 cm/sec for drifter 15087 and 45.25 for drifter 15088. The outline in the center of the figure represents the 180 m isobath surrounding the atoll.

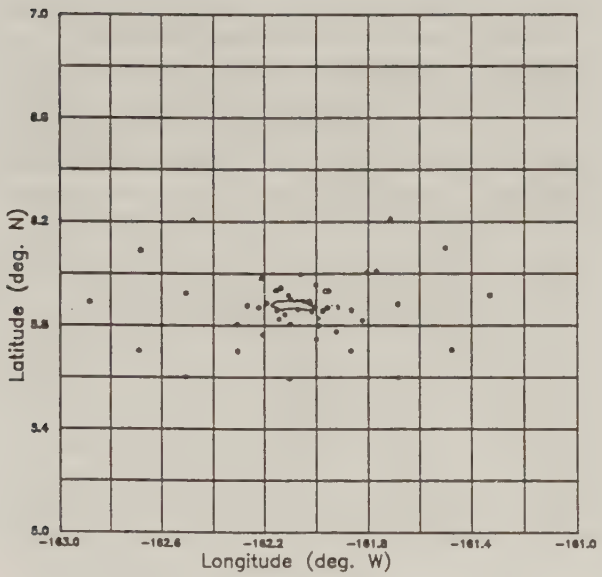

Figure 6. MOCNESS stations taken in the nighttime geographic series. Each asterisk represents the location of a station, which involved a single Manta tow and a single deployment of the MOCNESS (the latter with six plankton samples taken at three discrete depths). The outline in the center of the figure represents the 180 m isobath surrounding the atoll.

30-0 m. Plankton sorting and ichthyoplankton identification are in progress.

Additional daytime MOCNESS hauls were made to determine the distribution of inshore fish larvae relative to physical factors in shallow waters around the island. In this sampling, distinct differences were noted between the north and south flanks of the island platform in terms of the larvae and plankton present. Along the 250 fm isobath, ADCP measurements were made on both north and south flanks, and approximately equal sampling effort was expended in both locations. For comparison with the ichthyoplankton collected around the island, limited work was done in Palmyra Lagoon, which, despite a dredged entrance channel only 26 ft deep, has depths to 175 ft. On two short visits to the lagoon, CTD, ADCP, light trap, and ichthyoplankton drop-net samples were collected.

The results of this survey should provide important information to help understand the influence of advection on larvae inhabiting oceanic islands. The very high speed, unidirectional currents will make an interesting contrast with the relatively gentle currents noted in research conducted previously at Johnston Atoll, where an apparent retention area for island larvae was present in downstream waters. Additional information collected in the lagoon on this cruise should provide further information on the role of lagoons in maintaining larvae of selected species. (G. Boehlert (808) 943-1221)

PELAGIC RESOURCES INVESTIGATION

Manuscripts Completed on the Cardiac Physiology of Tunas

In the summer of 1990, a group of eight scientists from the University of British Columbia, Simon Fraser University, Massey University, and University of California, San Diego, visited the Kewalo Research Facility for a multidisciplinary study on the physiology and biochemistry of tunas. Two recently completed manuscripts based on these studies are: "Cardiac physiology in tunas: I. perfused heart preparations in yellowfin and skipjack tunas"; and "Cardiac physiology in tunas: III. coronary pressure-flow relationships in skipjack tuna." Coauthors of the manuscripts are A. P. Farrell, C. E. Franklin, J. Johansen, P. S. Davie, and R. W. Brill.

The manuscripts describe, for the first time, some of the unique aspects of cardiac function in tunas and explain how tunas are able to produce cardiac output more than an order of magnitude higher than other fishes. One of the surprising discoveries of these studies was that tuna hearts appear incapa-

ble of increasing cardiac output by increasing stroke volume (i.e., the amount of blood pumped per heart beat) as do other fishes. This result explains why cardiac output falls as heart rate falls during reduced ambient oxygen observed in the previous studies on the low ambient oxygen tolerance of tunas. In other words, the adaptations that tunas have evolved to permit exceptionally high cardiac outputs make them relatively intolerant to reductions in ambient oxygen. (R. Brill (808) 943-1234)

WESTERN PACIFIC FISHERY INFORMATION NETWORK

Update on Western Pacific Creel Surveys

Until 1990, three of the four flag-state Pacific islands had no laws requiring licensing or reporting of any kind for participants in their commercial fisheries. During 1990, American Samoa and Guam joined Hawaii in requiring licensing and reporting.

Historically, the lack of regulation made formalized methods for obtaining data on the commercial fisheries (which in some islands were quite substantial when calculated on a per capita basis) scarce, rudimentary, or non-existent. Therefore, from its beginning in 1981, the Western Pacific Fishery Information Network (WPACFIN) began assisting island fisheries agencies to develop and implement creel surveys as one of the useful tools of measuring and monitoring their fisheries. These surveys have become the backbone of monitoring the fisheries in many Pacific islands, and the data from them are used extensively by fishery management plan monitoring teams.

Unlike most creel-type surveys which typically focus on the recreational components of the fisheries, the surveys implemented in the western Pacific collect information on virtually all components of the fisheries, including recreational, subsistence, full- and part-time commercial, and in some cases, charter boats. Some islands also have separate surveys for non-boat-based fisheries (e.g. shoreline or inshore fisheries). In many of the Pacific islands, even the non-boat fisheries have important commercial components that harvest substantial quantities of reef fish and other resources such as lobster. Data are collected not only on the typical creel survey-type data elements such as catch, effort, and species composition (by method of fishing), but also on other elements such as the disposition of the catch and, in one case, the price paid for sold fish.

Although all surveys implemented through WPACFIN technical support are based on fairly standard design criteria, each island requires some customizing of the basic design to meet local needs and staff capabilities. The WPACFIN philosophy is to make the systems work for the local fisheries agencies, which in turn will work to meet federal requirements. Surveys of some sort are now being conducted in all of the flag states--American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and most recently, Hawaii. Surveys are also being conducted on several islands in the Federated States of Micronesia using the WPACFIN design as a template. Data from all of these areas are provided to the central WPACFIN office for use by fishery managers and scientists. Obtaining information from a wide range of Pacific island areas is essential to improving our understanding and monitoring of all fisheries, especially pelagic species. (D. Hamm (808) 943-1214)

PACIFIC FISHERIES ENVIRONMENT GROUP

Monterey, California

Comparative Study Made of the California Current, Benguela Current, and Patagonian Shelf Ecosystems

The California and Benguela Current systems are classic eastern ocean coastal upwelling systems with narrow to moderate continental shelves. The coastal ocean system off Argentina, Uruguay, and southern Brazil has a western ocean boundary setting and a vast expanse of continental shelf. All three systems feature small pelagic-spawning clupeoid fishes as essential trophic components. A manuscript being completed by PFEG Chief Andrew Bakun uses these three systems to construct an example of the rather indirect inferential process involved in drawing insights from an interregional comparative study. It turns out that this particular trio of ecosystems provides quite a convenient

framework for presenting some emerging generalizations concerning environmental regulation of the population dynamics of the small, pelagic-spawning, clupeoid fishes that are a vital trophic component of many of the marine ecosystems of the world ocean. The comparison also leads to some suggestions concerning the problem of predicting effects of global climate change on marine ecosystems.

Not surprisingly, three factors appear to act in combination to produce favorable reproductive habitat. These include: 1) enrichment of the food web via physical processes (upwelling, mixing, etc.); 2) opportunity for concentrated patch structure of food particles to accumulate (i.e., stability, lack of active turbulent mixing, and/or strong convergence in frontal structures); and 3) availability of mechanisms promoting retention of reproductive products within appropriate habitat. Although temperature variation is sometimes correlated with reproductive success, temperature variability may act as a surrogate variable for processes affecting enrichment, stability, retention, etc., as well as being a causative factor itself. For example, warm temperatures off California have seemed to be positively correlated with sardine recruitment success during the period since the famous collapse of that population in the 1940s and 50s, but negatively correlated in the earlier period of fishery growth and climax.

The Benguela system has the special attribute of having sources of warm water at both ends of the system. These occur not only on the tropical side, as is common in other coastal ecosystems, but also on the poleward side where warm Agulhas Current water from the Indian Ocean may flow around the southern end of the African continent and enter the Benguela system from the south (Figure 1). This attribute allows a degree of differentiation, unavailable in most other regional systems, between different types of warm events. The Benguela experience indicates that warm events representing tropical outbreaks similar to El Niño events have been generally detrimental, but that warm events may be beneficial to local recruitment when they promote influx into the local area from non-local population segments. If one transfers this experience to the California system, it would suggest that during the recent several decades, the association of increased sardine recruitment with warmer temperatures may largely reflect the influx (related to anomalously northward tendencies in flow and related properties, particularly during El Niño episodes) of southern subpopulation fish from their relatively lightly exploited refuge off southern Baja California. Because of the very low resident biomass, even a limited influx of younger fish from the south could show up as a substantial upsurge in local recruitment per unit resident spawning stock. Conversely, in the earlier period when the population center was off California, influxes of tropical conditions which are typically accompanied by lowered plankton productivity, etc., could have had adverse affects on local recruitment.

Figure 1. Characteristic summer (July-August) sea surface temperature (°C) distribution for the Benguela Current region (redrawn from Parrish et al., 1983). The area of the continental shelf is indicated by shading adjacent to the coastline. 'A' and 'S' symbols mark general locations of principal spawning grounds of anchovies and sardines, respectively.

Another indication that temperature may be an equivocal indicator comes from recent experience off western South America. The Brazilian sardine, a tropical *Sardinella* species, has apparently collapsed under heavy exploitation following a local warm environmental episode. Since the collapse, large quantities of anchovies of the genus *Engraulis* have been observed in the habitat. Such an apparent replacement of a warmer water species by a cooler water species during a warm environmental anomaly adds to the impression that it may not

generally be temperature itself which is the causative agent, but that temperature may be merely a correlate to dynamic processes affecting trophic enrichment, food particle concentration, and larval retention.

This has implications to the problem of predicting probable effects of global greenhouse warming on marine resources and ecosystems. If temperature is indeed an equivocal indicator of environmental effects on fish population dynamics, it will not suffice to merely upwardly increment presently-established empirical relationships between temperature and the population responses and distributions of marine organisms. The only situation in which such a procedure would seem to work reliably would be where a species may be at the edge of a range limit that is directly determined by physiological temperature tolerances and where the life style of the species is such that it is tied to the upper mixed ocean layer or shallow continental shelf regions and thereby prevented from compensating by adjusting its depth level.

One of the global greenhouse effects that we can be most certain about is an increase in warm season temperature contrast between the continental land masses and the oceans. This would lead to intensified sea breeze circulations and alongshore coastal winds. These increases in alongshore winds would be the equatorward direction along eastern ocean boundaries and poleward along western ocean boundaries (i.e., the directions that would, in each case, intensify offshore surface transport and coastal upwelling). Increased input of turbulent mixing energy to the upper ocean would also result.

Thus, greenhouse-related intensifications of coastal winds would appear capable of shifting the balance among enrichment, concentration, and larval retention processes in coastal ocean pelagic habitats. The atmosphere, having little heat capacity, will equilibrate very rapidly to greenhouse effects. The ocean, with its very large heat capacity, will respond much more slowly. Consequently, global greenhouse effects might totally reorganize marine reproductive habitat geography long before local temperature increases due to direct greenhouse heating are evident, particularly since associated intensifications of wind-induced upwelling and vertical mixing would act to cool, rather than warm, the ocean surface layers (A. Bakun (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Seychelles Purse Seine Data Updated

Biological Technician Gary Rensink has completed updating the third quarter 1990 Seychelles Fishing Authority data of tuna purse seiner catches in the western Indian Ocean. Data are summarized in LOTUS spreadsheets, and cover the period 1983 to the present.

The number of vessels participating in the purse seine fishery in the western Indian Ocean during the third quarter of 1990 reached a high of 45 in September (14 French, 21 Spanish, 2 Mauritian, 1 Panamanian, 4 Soviet, and 3 Japanese). This is much lower than the 54 vessels recorded in February 1990, and lower than the 49 vessels recorded for the same period in 1989.

Catch rates for the third quarter of 1990 averaged 22 metric tons (t)/day, significantly higher than those of the previous three quarters averaging 14 t/day, and were also higher than the 17 t/day recorded for the same period in 1989 (Figure 1).

Cumulative catches through September 1990 were 121,400 t, a decrease of 31% below catches for the same period in 1989 (Figure 2). The species breakdown of catches for the third quarter of 1990

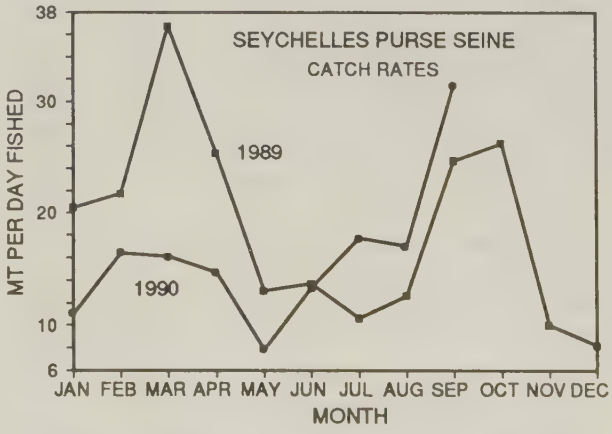

Figure 1. Catch rates (metric tons/day fished) for purse seiners fishing in the western Indian Ocean, 1989 and 1990.

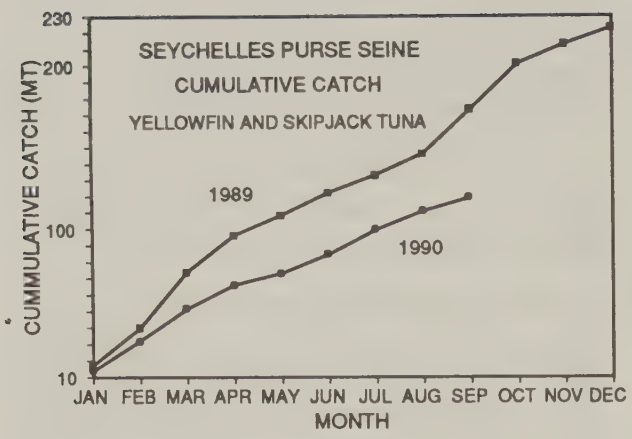

Figure 2. Cumulative catches (metric tons) for purse seiners fishing in the western Indian Ocean, 1989 and 1990.

was 45% yellowfin and 55% skipjack tuna, compared to 22% yellowfin and 78% skipjack tuna during the same period in 1989. Yellowfin tuna accounted for 83% of the catch for the month of July 1990. (A. Coan, FTS 893-7079)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Albacore Troll Fishery - High Seas Drift Net Interaction

Cheryl Brown and Dave Holts recently completed analysis of data collected by observers placed onboard U.S. albacore troll vessels in response to complaints from U.S. albacore fishermen about decreasing catches and substantial numbers of fish caught being damaged with gillnet marks. High-seas gillnet fisheries of Japan, Taiwan, and Korea in the north Pacific target on squid with small mesh nets and tuna with large mesh nets. These fisheries take albacore, and operate in areas where albacore concentrate during the trolling season.

In cooperation with the Western Fishboat Owners Association, SWFSC observers accompanied five U.S. troll vessels during the 1990 fishing season. The observers documented daily catches and recorded gillnet inflicted damage on albacore in the catch over a wide fishing area of the north Pacific Ocean (Figure 3). The resulting data provide minimum estimates of albacore encounter rates with the gillnet fisheries.

Six cruises were completed between the end of May and the beginning of October totaling 377 observed sea days in the Midway, offshore, and coastal fishing areas (Figure 3). A total of 19,526 albacore or 78% of all albacore caught, were examined and measured (both fork length and maximum girth), and 8,720 of these were also weighed. Overall, 87.2% of the catch examined showed no evidence of net related damage (Table 1). Recent gillnet damage occurred in 7.2% of the catch while 5.2% had healed scars from earlier net encounters.

Table 1. Proportion of albacore with gillnet damage in U.S. albacore troll catch.

	AREA OF CAPTURE			
	MIDWAY West of 160°W	OFFSHORE 160 to 140°W	COASTAL East of 140°W	ALL AREAS
NO DAMAGE (%)	81.6	82.8	90.7	87.2
FRESH MARKS (%)	17.5	11.7	4.1	7.2
OLD MARKS (%)	0.9	5.5	5.2	5.2
SAMPLE SIZE	218	7,440	11,868	19,526

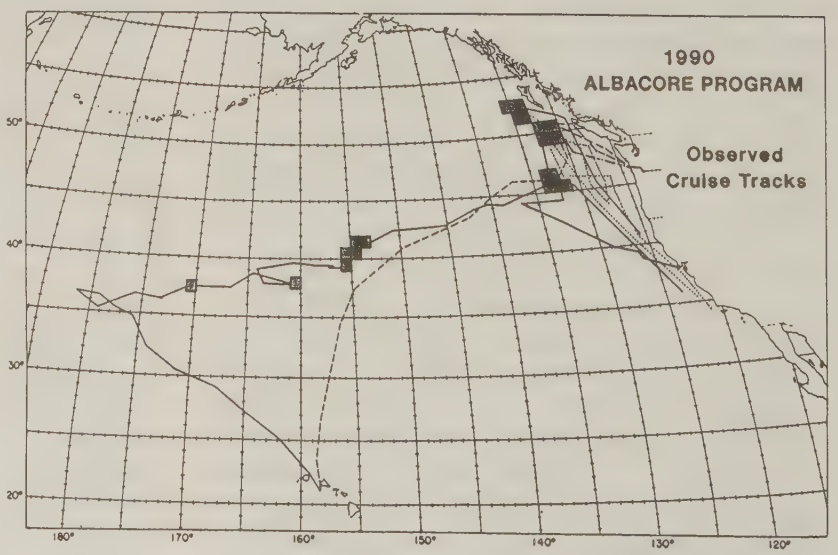

Figure 3. 1990 Albacore program - observed cruise tracks. Blocked shaded areas indicate primary fishing areas. Dotted, solid, and dashed lines indicate tracks of observed vessels.

Larger fish were caught west of 140°W than those caught east of 140°W (Figure 4a, 4b). These fish averaged 20-25 pounds and were taken in June and the first 2 weeks of July by vessels that departed Honolulu. Injuries from recent encounters with drift nets were observed on up to 18% of their catch. Old and healed scars from the previous season appeared on less than 1% of the catch west of 160°W but jumped to about 5% east of there.

By the end of July, all vessels were fishing east of 140°W and encountered smaller fish weighing 12 to 20 pounds. The incidence of gillnet injuries was lower at 4.1%, while the incidence of old injuries remained at about 5 percent. In August, large fish (20 to 25 pounds) were caught off Vancouver Island, British Columbia, and fishing remained moderately good north of 50°N until seasonal storms out of the Gulf of Alaska forced many vessels to return home by the end of September. Gillnet damage

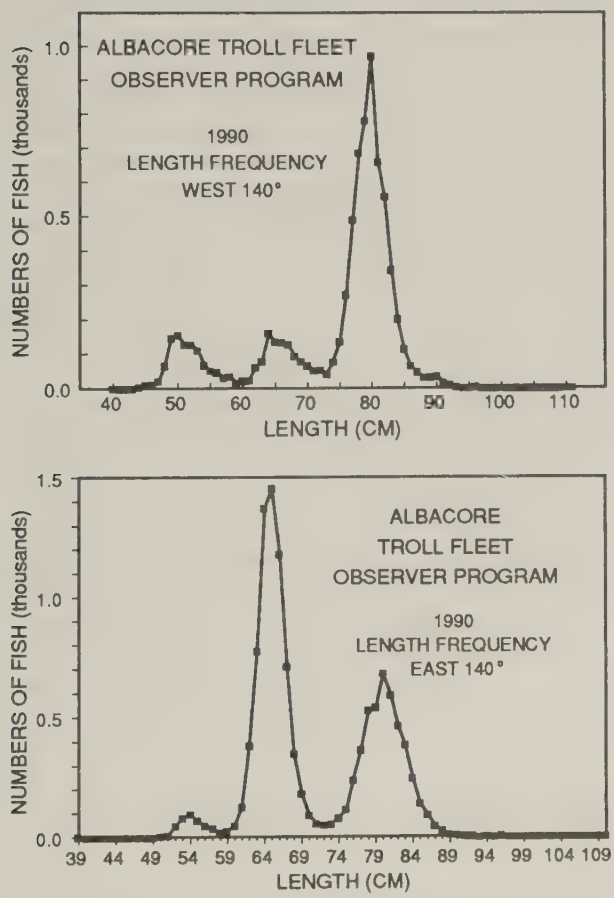

Figure 4a.(top) Length-frequency distribution of albacore caught west of 140°W. **b.**(bottom) Length-frequency distribution of albacore caught east of 140°W.

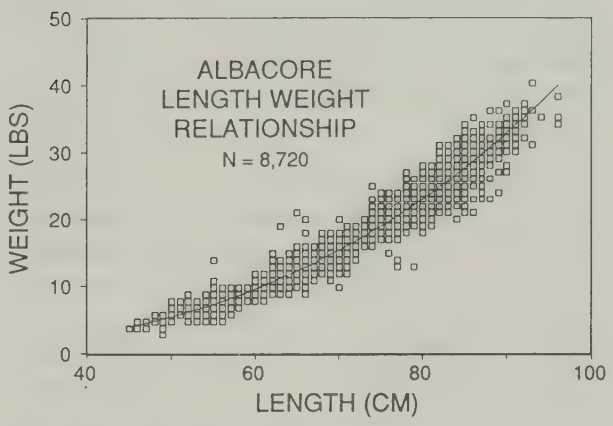

Figure 5. Albacore length-weight relationship.

rates in this northern area were about 5%, and no different from rates in the areas south of 50°N.

The length-weight relationship for albacore caught is shown in Figure 5. Preliminary analysis of fish with and without gillnet marks indicated no significant weight difference (i.e. no weight loss due to injuries from encounters with the high-seas gillnets).

Blood and tissue samples were collected from sub-groups of uninjured and injured fish, including fish that had recovered from previous injuries, to determine if disease or other abnormalities were occurring in the injured fish. Analyses of the samples are underway and will be reported when completed. (N. Bartoo, FTS 893-7073)

Albacore Reproduction Biology Project Begun

A project to examine the spawning biology of Pacific albacore and its relation to recruitment got underway in September with the acquisition of laboratory equipment. This project is being conducted by Fishery Biologists Norman Bartoo and Darlene Ramon, in collaboration with foreign scientists.

The equipment for the project consists of an integrated image capturing system composed of an Olympus SZH dissecting microscope, a Cohu solid state camera and a Macintosh IIcs computer with a Data Translation Quickcapture board installed to capture and process images. The system measures oocyte diameters and records data for later analysis with computer programs Excel or Macspin.

Through December 1990, albacore gonads from both the north and south Pacific have been received

from several sources, including the South Pacific Commission, the Honolulu Laboratory, and the National Research Institute of Far Seas Fisheries in Japan. The gonads will be examined in the coming months.

Seventy-four albacore, ranging in size from 78 to 92 cm, were collected between August 7 and September 24, 1990, by SWFSC observers aboard U.S. troll vessels in the north Pacific. To test the effects of preservation in the laboratory analysis, the right gonad from these fish was preserved in formalin while the left gonad was frozen. The results indicate that either method is satisfactory for preserving the gonads and for determining levels of maturity in immature and early developing fish, but they also showed that the size of ova in pairs of ovaries was different. This difference might be related to the preservation method or to actual physical asymmetry in ova sizes associated with differences in weights between the right and left ovaries. A detailed study of this finding is planned. (N. Bartoo and D. Ramon, FTS 893-7073)

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Computer Modelling Of Longline Fishing

Operations Research Analyst Carlos Salvadó and Fishery Biologist David Au have completed a computer program that models the random movement of fish in the vicinity of a hook. At the heart of the model is the assumption that the foraging speed of fish is proportional to P^a, where P is the population density of fish exploited by the fishery and $0<a<1$. Parameters of the model that can be adjusted to examine different situations are:

1. The number of fish in the exploited population which affects the foraging speed of the fish.

2. The effective radius of capture of the hook which is dependant on the smell emanating from the bait on the hook.

3. The maximum time interval between changes of movement of the fish in random directions.

This model will form the basis of a study of catch rate versus population characteristics of tunas and for a study on analysis of optimal foraging strategies, including foraging for sparse and ephemeral food patches, and the efficacy of frenzied feeding, in tropical pelagic species. (C. Salvadó, FTS 893-7052; D. Au 893-7071)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Research Cruise is Conducted to Study Outer-Slope Communities

Members of the Groundfish Communities Investigation sampled groundfish communities on the outer-slope of the continental shelf off Oregon during November. Pete Adams, Ralph DeFelice, Tom Laidig and Kelly Silberberg worked from the NOAA Ship *Miller Freeman*, of the Alaska Fisheries Science Center, to study distribution and food habits of groundfishes at depths between 100 and 700 fathoms. Over 2,100 stomach samples were taken from fishes of the deep-slope community, most of which were from the four major species and included: sablefish (*Anoplopoma fimbra*), shortspine thornyhead (*Sebastolobus alascanus*), longspine thornyhead (*S. altivelis*) and Dover sole (*Microstomus pacificus*). Two other species, the deepsea sole (*Embassichthys bathybius*), and the giant grenadier (*Albatrossia pectoralis*), were also sampled. The deepsea sole was taken for a comparison with the Dover sole, as the two are very similar in morphology and distribution, and the giant grenadier was taken because it is a large and prominent piscivorous predator in the deep-slope habitat.

The broad range of depths covered during this survey permitted comparisons of species structure and distribution between deep-slope fishes and their relatives in shallower water. Catches of the deep-slope species proved remarkably consistent in number and composition, in striking contrast with the patchy distribution typical of the shallower rockfish and flatfish complexes. (P. Adams, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Paper on Depth Distribution of Juvenile Fish Presented at CalCOFI Meeting

Fishery Biologists William H. Lenarz and Stephen Ralston co-authored a paper with Ralph J.

with the patchy distribution typical of the shallower rockfish and flatfish complexes. (P. Adams, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Paper on Depth Distribution of Juvenile Fish Presented at CalCOFI Meeting

Fishery Biologists William H. Lenarz and Stephen Ralston co-authored a paper with Ralph J. Larson (San Francisco State University) entitled "An in-depth review of the depth distributions of early life history stages of important fishes of the California Current." Depth distributions of young stages of fish are of interest because these fish are thought to be advected by currents and current directions and strengths are often related to depth within the water column. The paper, presented at the CalCOFI Meeting at Asilomar on October 31 provided results obtained from data collected by pelagic juvenile rockfish mid-water trawl surveys off central California.

The authors found that in late March and early April large larvae and small juveniles of five species of rockfish inhabit depths in the water column that are similar to depths reported in the literature for small unidentified rockfish larvae. The average depth is about 30 m, which is approximately the depth of the thermocline. By late May and early June, most of the fish are large pelagic juveniles and the average depth increases by about 20 m for the five species. The increase in depth may be a response to the increase in upwelling and consequent offshore currents at shallow depths that occur between the two periods.

Depth data were available for juveniles of 15 species of rockfish, 2 species of flatfish, Pacific whiting, and northern anchovy for the May-June period. The average depth for these species was 56 m. Boccaccio was the shallowest species (30 m), followed by darkblotched rockfish (34 m), and northern anchovy (42 m). Pygmy rockfish, the deepest species (83 m), was followed by blue rockfish (79 m) and rex sole (69 m). The average depth of most species was between 50 and 65 m.

During the May-June period, considerable data were available for shortbelly rockfish, the most abundant rockfish, during the May-June period. It was found that relatively few small specimens were captured by shallow tows, in contrast to the overall increase in average depth found between the early and late periods when the fish are growing considerably. Since small fish are more subject to advection, they may be avoiding the upper water column during the May-June upwelling period.

The authors are preparing a manuscript for publication in CalCOFI Reports. (W. Lenarz, FTS 556-0565)

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Poor Condition of Yellowtail Rockfish Observed at Cordell Bank

The objective of this program is to relate measures of condition in adult yellowtail rockfish to their reproductive success, and to determine the relationship of annual and geographic variability in these factors to juvenile abundance and recruitment

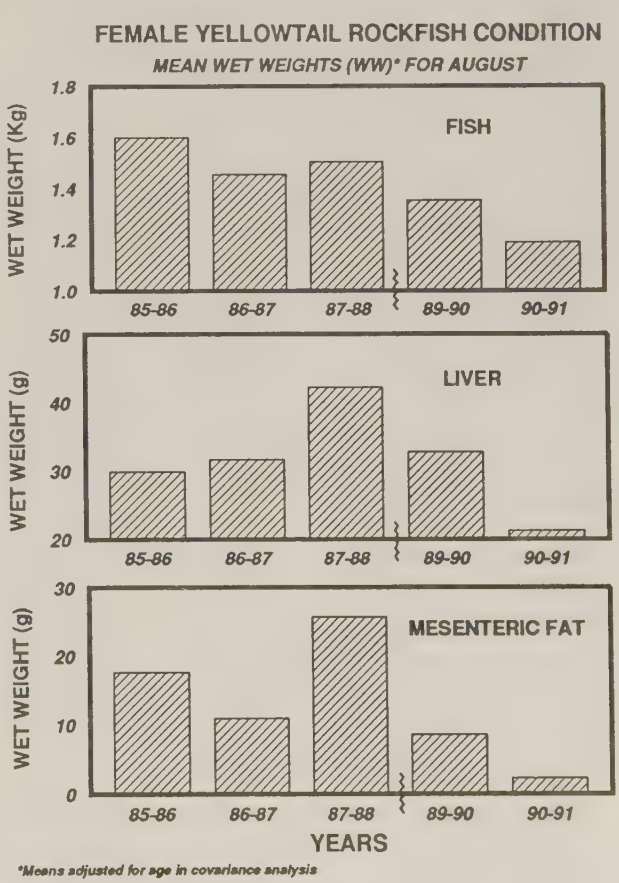

Figure 1. Annual variability in somatic condition factors for female yellowtail rockfish (weights adjusted for age by covariance analysis).

gust of this spawning year (April 1990 through March 1991). Most of the lowered condition is a result of less lipid in tissues (see below). The oldest fish in the samples were in the worst condition.

In addition, significantly ($P<0.05$) increased severity and prevalence of diseases such as the fungus *Icthyophonus hoferi* and melanophoromas was noted, particularly in September. Again, the most deleterious conditions were noted in the older fish. Further reports on studies of melanophoromas from Dr. Mark Okihiro, University of California, Davis, indicate that the external melanophoroma metastasizes with tumors occurring in liver tissues of some fish. This strengthens earlier assumptions that these tumors probably result in death in some of the older yellowtail rockfish. Work on this aspect of the study is nearing completion and a manuscript is in preparation.

It is uncertain whether or not this lowered condition will relate to effects in reproduction and effective fecundity this year. There may be some reduction of gonad weights and/or delay in gonad maturation occurring, as exhibited in Figure 2. There was significantly lower gonad weight ($P<0.05$) in females collected during August just prior to onset of maturation.

We are still collecting fish during the spawning season, so final conclusions about this spawning season cannot be made. More recent examinations showed that there was less mesenteric fat continuing through November, but that in December some younger fish may have recovered sufficiently to reproduce normally. Observations of older fish, however, indicate that they still have lower gonad weights and/or delayed maturation. We will know more about this after histological sections are examined and data analyzed.

The poorer condition last summer may relate to decreased upwelling during spring and summer and reduced food availability. Monthly upwelling means calculated for 39°N latitude for 1990 are much lower than mean values for the 1980-1989 period (data summarized by B. Jarvis and C. Callahan from upwelling indices obtained from PFEG).

Analyses of food types and amounts in stomachs of yellowtail rockfish (Table 1) captured during the summer of 1990 showed that the largest amounts of euphausiids were found in stomachs in June. *Euphausia pacifica* was by far the more common euphausiid found in stomachs, occurring throughout the summer; *Thysanoessa spinifera* was found in

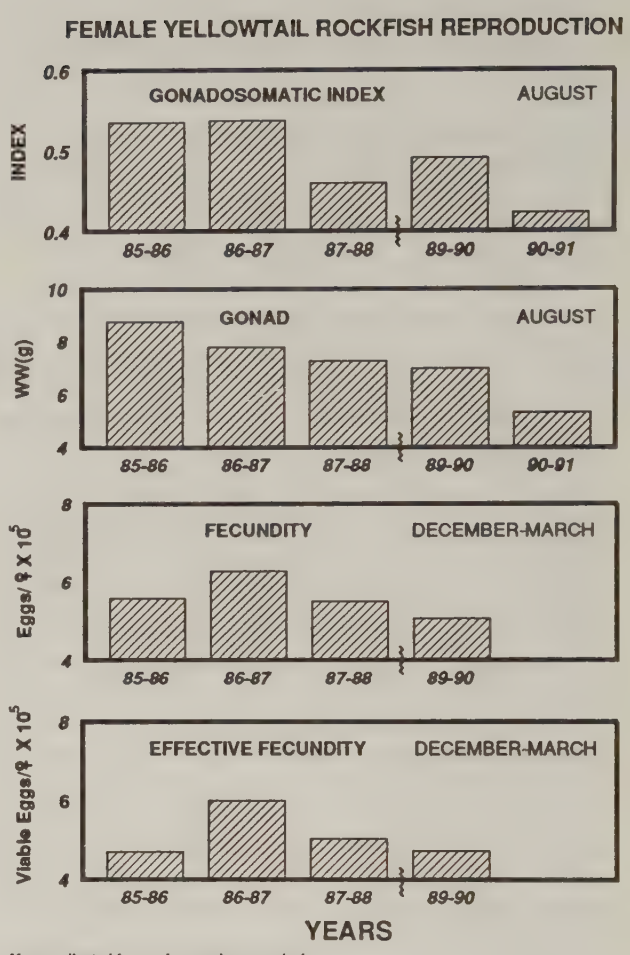

Figure 2. Annual variability in reproductive factors for female yellowtail rockfish (weights adjusted for age by covariance analysis).

Table 1. Mean wet weight of euphausiids (g) in stomachs of *S. flavidus*[1].

MEAN WET WEIGHT OF EUPHAUSIIDS (g) IN STOMACHS OF *S. flavidus*[1]

MONTH	*E. pacificus*	*T. spinifera*	Unident.	Total
April	4.81 (15)	0.00 (0)	0.00 (0)	4.81
May	3.60 (10)	0.34 (5)	2.00 (4)	5.94
June	3.17 (11)	2.43 (9)	3.07 (10)	8.67
July	3.26 (6)	0.33 (3)	3.03 (3)	6.62
August	0.47 (1)	0.35 (1)	2.92 (2)	3.74

[1]Means based only on fish with euphausiids in stomachs; number of stomachs with euphausiids out of 20 fish sampled shown in parentheses.

smaller numbers, mostly in June. Stomachs of many fish, however, were empty at time of capture. These results will be compared to feeding during more average environmental conditions. (J. Whipple, FTS 556-0565)

Lectures and Papers Presented

On Thursday, October 25, Jeannette Whipple gave a lecture at the College of Natural Resources at the University of California, Berkeley, on effects of environmental degradation on fisheries. Following the lecture, discussions were held with students who were interested in environmental research and cooperative fellowships with NMFS.

Dr. Jeannette Whipple gave a presentation at the Gulf of Farallones Session at the meetings of the American Geophysical Union held on December 3 in San Francisco, entitled "Fish as harbingers of environmental change." (J. Whipple, FTS 556-0565)

Nutritional Status of Yellowtail Rockfish Updated

Concentrations of important nutritional components have been followed in adult yellowtail rockfish (*Sebastes flavidus*) from the Cordell Bank population since April 1985. The objectives of this project are to develop a predictive model of annual reproductive success containing nutritional variables, and to compare interannual variations in the nutritional, or energetic status of the female population.

Well developed annual patterns of concentrations of protein, carbohydrate, and lipid components in liver, muscle, gonad, and blood have been shown to be consistent over six reproductive cycles. There was little difference in the amplitudes of individual nutrient cycles during the first 4 years of the study (April 1985 through December 1988) and, therefore, the magnitudes of the cycles were considered to be typical of the species in the Cordell Bank habitat. However, since December 1988, data show decreased concentrations of several significant nutritional components, particularly lipids and vitellogenin (measured by the surrogate, serum calcium).

During the last complete reproductive cycle, April 1989 through March 1990, decreased concentrations of serum lipids (triglycerides, non-esterified fatty acids [NEFA], cholesterol, and phospholipids), albumin, vitellogenin, and glucose were indicated. However, the extent of energy depletion, and consequently the association with reproductive output, could not be discerned due to a modified, and less frequent, sampling schedule. For the present reproductive cycle, monthly sampling was resumed. An evaluation of the data generated to date (through November) revealed that the accumulation and circulatory transport of energetic nutrients was decreased during mid to late summer, the normally heavy feeding period (Figure 3). Serum triglyceride levels during July, August and September 1990, indicative of the intensity of feeding, were significantly lower ($P<0.0001$) than during the first four reproductive cycles (1985-1989) (Figure 3a). Likewise, vitellogenin transport was diminished since June 1990 relative to previous annual cycles ($P<0.001$) (Figure 3b). Ovary, and particularly liver lipid levels were also reduced ($P<0.05$) during the summer feeding period (Figure 3c and d). This was consistent with decreased mes-

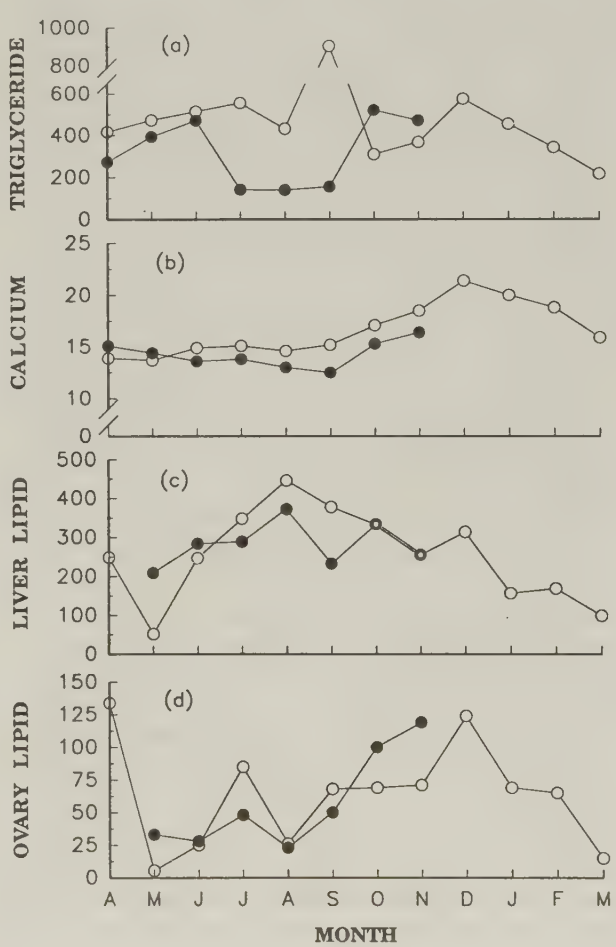

Figure 3. Changes in concentrations of (a) serum triglycerides (mg/dl), (b) serum calcium (mg/dl), (c) liver lipid (mg/g), and (d) ovary lipid (mg/g) in female yellowtail rockfish during reproductive cycle. Mean monthly values for specimens obtained from the present cycle (solid circles) are compared with mean monthly values from females collected between April 1985 and December 1988 (open circles).

enteric fat reserves. Through September 1990, it was apparent that adult female yellowtail rockfish were nutritionally and energetically depleted. Also, during the late summer, visual inspection of the ovaries revealed retarded development of oocytes. It appeared that feeding and, thus nutritional state were greatly diminished, a finding that may have a significant impact on reproduction this year.

Data from specimens collected during the last 2 months, however, revealed that the population is in a better nutritional state. Presumably, transport of triglycerides (as well as NEFA, phospholipids, cholesterol, and albumin), for ovarian maturation, has increased at least partly (if not mostly) to above typical levels ($P<0.01$) (Figure 3a). Ovaries have higher than typical lipid concentrations ($P<0.0005$), and liver lipid has recovered to average values. Ovarian development seems to have accelerated and is now on schedule with the normal temporal pattern. These data would seem to suggest that the yellowtail rockfish at Cordell Bank have increased feeding during the months of October and November, when food supply or feeding usually is reduced, and have compensated for decreased energy storage during the summer. Whether sufficient nutrition and energy is available to complete ovarian maturation to optimum production of healthy larvae, either from intramaternal sources or the environment, remains to be determined. The quantity and quality of progeny for this cycle will be more evident when embryonic and larval stages are present and analyzed, usually during January through March. (B. MacFarlane, FTS 556-0565)

Relative Fecundity of Yellowtail Rockfish

An understanding of reproductive life history is needed for effective management of fish stocks because management decisions can result in changes in the reproductive capacity of a stock. From 1985 to the present, we have sampled yellowtail rockfish from Cordell Bank, California, to assess their physiological conditions and reproductive efforts. In previous bimonthly reports we have presented findings on absolute fecundity, the total number of eggs produced by an individual fish within a reproductive season.

Another perspective of yellowtail rockfish reproduction is gained by examining the relative fecundity, the number of eggs per unit weight of somatic tissue. A total of 260 adult female yellowtail rockfish representing five consecutive reproductive seasons beginning in 1985, were examined (Table 2). When the relative fecundities were compared, no statistical difference was found (Analysis of Covari-

Table 2. Summary statistics of the relative fecundities (number of eggs/g somatic tissue) of yellowtail rockfish from Cordell Bank, CA, from 1985-1990.

Year	n	Mean	S.D.	Min.	Max.
85/86	22	436.95	96.15	190.13	572.41
86/87	64	431.13	128.95	113.12	723.49
87/88	64	325.12	138.25	96.17	686.05
88/89	28	427.04	147.46	129.53	674.11
89/90	82	407.12	86.75	212.60	636.76
Combined	260	397.51	126.07	96.17	723.49

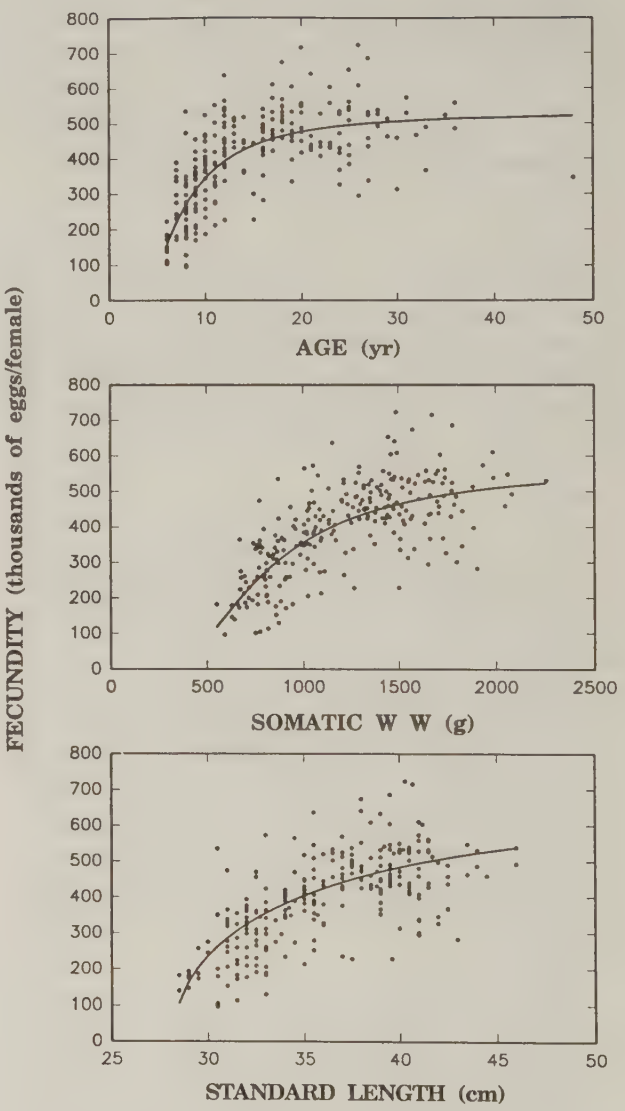

Figure 4. Relative fecundities of yellowtail rockfish in relation to age, whole body somatic wet weight, and standard length.

ance, P>0.05), although the mean value for the 1987-1988 season was considerably lower than those of other years. This contrasted with our findings of absolute fecundities in which there were significant differences between years, 1987-1988 being low and 1988-1989 being high.

The lack of significant interannual differences in relative fecundities allowed the pooling of years for the study of the relationship between relative fecundity and age, somatic wet weight, and standard length. In all three comparisons, relative fecundities showed initial rapid increases that moderated with advancing age and size (Figure 4). This was especially evident with age in fish over approximately 15 years of age. The descriptive linear equations for these relationships are as follows:

Age	$Y = 247.4593 + 10.09155X$, $r^2 = 0.345$
SL	$Y = -370.793 + 21.196X$, $r^2 = 0.440$
SomWW	$Y = 115.5112 + 231425X$, $r^2 = 0.453$

Studies are presently underway that will contrast and compare physiological conditions and environmental conditions among the 5 years. Early findings indicate that there were differences among years in conditions, notably in the mesenteric fat deposits, and differences in storm activity, upwelling, and sea surface temperatures. It is interesting to note that despite differences in these inherent and environmental conditions, yellowtail rockfish did not alter their weight-specific egg production. This provides an example of the broad adaptive reproductive capacity of yellowtail rockfish. (M. Eldridge, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

Improved LAN Access for Remote Users

Until recently, users of the La Jolla 3COM network dialing-in from remote locations have been restricted to using 3+Remote software to access the network. Although the software interfaced the remote PC with the network operating system and made it appear as though the PC was network connected, the connection relied on the use of relatively slow modems which move data at a rate of 1200 to 2400 bits per second. Because of this limitation, the 3+Remote software was configured to give remote users access to the network's email service and nothing more. This form of usage was effective in providing message and file exchange capabilities, but was felt by our remote users to be tedious and aggravating. In addition, 3+Remote only runs on DOS PCs, so users in remote locations without access to DOS PCs were unable to connect to the La Jolla network or its email service.

Recently, things have improved greatly for remote users of the La Jolla network. The pcANYWHERE III remote access software has been installed on an ITS Dell 286 system, which is directly connected to the network. This PC, configured as a host system that can be accessed by users at remote locations, runs applications at speeds typical of a 12 Mhz 286 workstation. The pcANYWHERE host uses a high speed Telebit Trailblazer 19.2 Kbps modem and supports remote connections by both PCs and Macintosh systems. Identical Trailblazer modems have been purchased for PFEG, Tiburon, and Honolulu. Not only does use of these modems on both sides of the remote session tremendously increase the speed of running network applications, but more importantly, in this configuration only keystrokes and "screens" are passed back and forth between the pcANYWHERE host and the remotes (except when file transfers are initiated by the remote user). Since applications are carried out on the host PC rather than on the remote PC, network applications like dBASE III+ can be executed by remote users with no dBASE III+ on their remote PC. Early tests run from PFEG included file exchanges and interactive access of the a developmental version of the Financial Reporting System (FRS) by a PFEG Macintosh system. The developmental FRS system runs in a DOS environment on the 3COM network coded in dBASE III+, and is in the process of being converted from dBASE II on the Molecular 32X (which is being phased out). The pcANYWHERE III remote access software and Trailblazer modems will be shipped to the Tiburon and Honolulu Lab's in the near future. (F. Ralston, FTS 893-7062)

PUBLICATIONS

Published

Barlow, Jay. 1990. A birth-interval model for estimating cetacean reproductive rates from resighting data. Rep. Int. Whal. Commn (special issue 12):155-160.

Three approaches are examined for estimating reproductive rates from data on multiple resighting of dis-

tinctly marked animals. The three approaches correspond to parameter estimation for three population growth models. Two of the approaches, parameter estimation for the Leslie matrix and geometric series models, are based only on known-aged individuals. A third approach, the birth-interval model, is developed making fuller use of available information. The birth-interval approach uses only known-aged individuals to estimate the first-birth ogive and uses all females with previous births to estimate the probabilities associated with various birth intervals. A Monte Carlo simulation is used to examine the bias and precision of the three methods given the quantity of data that is usually available in a multiple resighting study. All three approaches appear capable of giving unbiased estimates of population growth rate. The variance associated with such estimates is greatest for the Leslie model, less for the geometric series model, and least for the birth-interval model.

Bushnell, P. G., R. W. Brill, and R. E. Bourke. 1990. Cardiorespiratory responses of skipjack tuna, *Katsuwonus pelamis* yellowfin tuna, *Thunnus albacares*; and bigeye tuna, *T. obesus*, to acute reductions of ambient oxygen. Can. J. Zool. 68:1857-1865.

Cardiorespiratory responses to acute reductions of ambient oxygen were measured in skipjack, *Katsuwonus pelamis*; yellowfin, *Thunnus albacares*; and bigeye tunas, *T. obesus*. Prevented from swimming by a spinal injection of lidocaine, fish were placed in seawater flowing at a velocity equivalent to their normal swimming speed. Ventilation volume (V_g), heart rate, cardiac output, mouth gape, and inspired water and exhalant water oxygen partial pressures (P_{iO2} and P_{eO2}, respectively) were simultaneously measured during periods of full oxygen saturation (normoxia) and brief (ca. 3-4 min) periods of reduced oxygen (hypoxia). During hypoxia, P_{iO2} ranged from 140 to 50 mmHg.

Ventilation volume during normoxia was significantly different in skipjack, yellowfin, and bigeye tunas (6.7, 3.9, and 1.5 $L \cdot min^{-1} \cdot kg^{-1}$, respectively) and paralleled differences in oxygen consumption (740, 455, and 322 mg $O_2 \cdot kg^{-1} \cdot h^{-1}$). All three species were sensitive to P_{iO2}, and mild hypoxia ($P_{iO2} \approx 115$ mmHg) elicited significant cardiorespiratory adjustments, including increased mouth gape and V_g and reduced heart rate. Cardiac output was maintained until P_{iO2} reached 95 mmHg, but at lower oxygen levels, it too began to decrease. Therefore, the three tuna species studied appear as sensitive to hypoxia as other marine teleosts and show cardiorespiratory adjustments at P_{iO2}'s, well above those eliciting swimming speed changes.

Henderson, J. R., and M. R. Finnegan. 1990. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project at Kure Atoll, 1988. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-150, 24 p.

Holland, K. N., R. W. Brill, and R. K. C. Chang. 1990. Horizontal and vertical movements of Pacific blue marlin captured and released using sport fishing gear. Fish. Bull., U.S. 88:397-402.

This paper reports on the movements of six Pacific blue marlin tracked using ultrasonic depth sensitive transmitters in the waters around the Hawaiian Islands. Of particular interest were the survivorship and behavior of the fish immediately upon release, their patterns of vertical movement, and their overall patterns of horizontal movement. To discern any common patterns of movement associated with one particular area of ocean, three fish were caught and tracked from one well-defined location on the Kona coast of Hawaii. For comparison, two other tracks were initiated several miles away along the same coast, and one marlin was tracked off the Waianae coast of Oahu.

Despite the commercial and recreational importance of Pacific blue marlin, *Makaira nigricans*, little is known about their biology or behavior. Recovery of tagged marlin has enhanced our understanding of the long-term geographical range of individual fish and their minimum rates of travel. However, this technique cannot answer questions regarding the vertical movements of marlin, their survival following the trauma of capture and tagging, and the nature of their behavior immediately upon release.

In this study, upon release all six marlin dove into the upper layers of the thermocline and remained there for several hours. Onset of consistent upward excursions from the thermocline appeared to represent the end of the post-capture recovery period--usually between four to six hours. The recovery period was characterized by comparatively high speed swimming, with four of the six fish tracked traveling farther in the first hour following release than at any other time. Because marlin are obligate ram-ventilators, these fish may be swimming fast enough to repay the anaerobic metabolic debt incurred during the fight, but not so fast as to acquire new debt. The fast speeds of the first hour are even more remarkable considering that at least two of the fish appeared to be completely exhausted when released.

One of the most remarkable features of the current study is the consistent direction of movement displayed by the marlin in the first several hours of each track. All fish swam along parallel courses which took them directly offshore. Also, initial deviation from these parallel tracks occurred in the same general area about 12 nmi offshore. These results suggest that direct movement offshore may be a common response to the trauma associated with capture and release. The first major horizontal direction changes often coincide with changes in vertical behavior and may represent the end of the recovery period.

Holland, K. N., R. W. Brill, and R. K. C. Chang. 1990. Horizontal and vertical movements of yellowfin and

bigeye tuna associated with fish aggregating devices. Fish. Bull., U.S. 88:493-507.

The horizontal and vertical movements of yellowfin tuna, *Thunnus albacares*, and bigeye tuna, *T. obesus*, captured near fish-aggregating devices (FADs) were determined using pressure-sensitive ultrasonic transmitters. The movements of these FAD-associated fish were compared with the tracks of yellowfin tuna not associated with FADs. Tracks from 11 yellowfin and 4 bigeye tuna were obtained; these included 23 complete 24-hour periods of observation. Whether associated with FADs or a 40-fathom (75-m) reef dropoff, most yellowfin and bigeye tunas exhibited similar diurnal patterns. The fish tended to remain tightly associated with FADs or the reef dropoff during the day, move away at night, and return the next morning. The maximum range of these nighttime excursions averaged approximately 5 nmi. These tunas apparently treated the FADs as outliers of the coastal topography. This may not be the same behavior that results in the association of these species with drifting objects such as logs. Tuna can learn FAD positions and navigate precisely between FADs that are at least 10 nmi apart. When not associated with FADs or the 40-fathom dropoff, yellowfin tuna oriented to the bottom of the mixed layer (50-90 m) in daytime, whereas the bigeye occupied depths between 190 and 250 m. The daytime distribution of bigeye tuna seemed to be influenced by the depth of the 15°C isotherm. Both species swam closer to the surface at night. Swimming strategies possibly associated with energy and thermoconservation were observed.

Holland, Robert C. 1990. A personal computer based system for analog-to-digital and serial communication data acquisition. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-152, 26 p.

Holts, David and Dennis Bedford. 1990. Activity patterns of striped marlin in the Southern California Bight, pp. 81-93. *In:* Richard H. Stroud (ed.), Planning the future of billfishes. Proc. Int. Billfish Symp., Kailua-Kona, HI, August 1-5, 1988. Mar. Rec. Fish. 13, Cont. Pap., Part 2.

Johanos, T. C., B. L. Becker, M. A. Brown, B. K. Choy, L. M. Hiruki, R. E. Brainard, and R. L. Westlake. 1990. The Hawaiian monk seal on Laysan Island, 1988. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-151, 34 p.

Mangel, Marc and Paul E. Smith. 1990. Presence-absence sampling for fisheries management. Can. J. Fish. Aquat. Sci. 47:1875-1887.

It is often important to estimate the abundance of a fish stock when the stock is somewhat depleted. For pelagic species this presents great operational difficulties, because adult surveys may be prohibitively expensive and time consuming. Here we introduce a method for estimating the spawning biomass of a stock by means of egg or larval surveys. In particular, we develop a series of models for presence-absence sampling of eggs or larvae and show how presence-absence data can be used to estimate adult spawning biomass. The models are based on an underlying probabilistic description of the aggregation of eggs or larvae, a search process, and a description of habitat structure. Methodologies are given for estimating the distribution of the size of the spawning biomass from presence-absence data. A case study of sardine is used to justify a number of the assumptions. The methods are applied to a 1985 survey for sardine eggs and are compared to an alternative method based on egg production.

Perrin, William F. 1990. Handbook of marine mammals--Volume 4: River dolphins and the larger toothed whales. *In*: Sam H. Ridgway and Sir Richard Harrison (eds). Academic Press, San Diego, CA. Mar. Mammal Sci. 6(4):356-358.

Reilly, Stephen B. and Victoria G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. Mar. Mammal Sci. 6(4):265-277.

The distribution of blue whales, *Balaenoptera musculus*, in the eastern tropical Pacific (ETP) was analyzed from 211 sightings of 355 whales recorded during research vessel sighting surveys or by biologists aboard fishing vessels. Over 90% of the sightings were made in just two areas: along Baja California, and in the vicinity of the Costa Rica Dome (a large, stationary eddy centered near 9°N, 89°W), with the rest made along the equator near the Galapagos Islands, the coasts of Ecuador, and northern Peru. All sightings occurred in relatively cool, upwelling-modified waters. Because these areas are the most productive parts of the ETP, and have relatively large standing stocks of euphausiids, it seems possible that blue whales select low latitude habitats which permit foraging. The waters off western Baja California were occupied seasonally, with a peak in sightings coinciding with the spring peak in upwelling and biological production. The Costa Rica Dome area was occupied year round, suggesting either a resident population, or that both northern and southern hemisphere whales visit, with temporal overlap. The modal group size was one for all areas and seasons, but the frequency of groups with two or more whales was significantly higher in sightings made near the Galapagos Islands and the coast of Ecuador and northern Peru.

Squire, J. L. and D. W. K. Au. 1990. Striped marlin in the northeast Pacific--A case for local depletion and core area management, pp. 199-214. *In:* Richard H. Stroud (ed.), Planning the future of billfishes. Proc. Int. Billfish Symp., Kailua-Kona, HI, August 1-5, 1988, Mar. Rec. Fish. 13, Cont. Pap., Part 2.

Squire, James L. and Ziro Suzuki. 1990. Migration trends of striped marlin (*Tetrapturus audax*) in the Pacific Ocean, pp. 67-80. *In:* Richard H. Stroud (ed.), Planning the future of billfishes. Proc. Int. Billfish

Symp., Kailua-Kona, HI, August 1-5, 1988, Mar. Rec. Fish. 13, Cont. Pap., Part 2.

Wilson, C. D. and G. W. Boehlert. 1990. The effects of different otolith ageing techiques on estimates of growth and mortality for the splitnose rockfish, *Sebastes diploproa*, and canary rockfish, *S. pinniger*. Calif. Fish Game 76:146-160.

Different ageing techniques affect not only the estimates of length at age but also estimates of population growth and mortality rates. This study considers these effects for the splitnose rockfish, *Sebastes diploproa*, and canary rockfish, *S. pinniger*, based on ages determined from the surfaces and sections of otoliths collected during a trawl survey off the west coast of North America in 1980. Estimates of growth based on surface rather than section ages were nearly identical for *S. diploproa* but were higher for *S. pinniger*; slightly different whole otolith ageing techniques are suspected of producing these interspecific differences. For both species, however, estimates of mortality were reduced by more than half when section rather than surface ages were used.

Approved by Science and Research Director, SWR

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